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# EFFECT OF SILT AND SILT REMOVAL IN A PRAIRIE LAKE

Clyde K. Brashier, et al

Environmental Protection Agency
Washington, D.C.

July 1973

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# Effect of Silt and Silt Removal In A Prairie Lake

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27 Abstract

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During the summers of 1969 and 1970 a total of seventeen gabion-type silt traps were constructed across the major feeder streams on the Lake Herman watershed in order to retard lake siltation. The traps were of several structural types and were constructed in locations with different types of creekbeds and different water-flow rates in order to evaluate which combinations of design and location were most effective. The traps were successful as filters for large debris but had limited success as silt-retaining devices. However, erosion occurred around or under many of the traps thus diminishing their effectiveness. (EPA)
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# EFFECT OF SILT AND SILT REMOVAL
# IN A PRAIRIE LAKE

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# ABSTRACT

A surveillance program has been maintained on two shallow, warm water prairie lakes and their tributaries. One of these lakes, Lake Madison, is domestically polluted with the effluent from the sewage treatment plant of Madison, South Dakota. The other, Lake Herman, is polluted due to siltation caused by run-off from a large, intensively farmed watershed. This surveillance program has resulted in comparisons of chemical nutrients and biota of a heavily silted lake with those of a relatively unsilted, but domestically polluted lake. The surveillance program on the Lake Herman tributaries has also led to conclusions regarding nutrient levels in successive spring run-offs.

During the summers of 1969 and 1970 a total of seventeen gabion-type silt traps were constructed across the major feeder streams on the Lake Herman watershed in order to retard lake siltation. The traps were of several structural types and were constructed in locations with different types of creekbeds and different water-flow rates in order to evaluate which combinations of design and location were most effective. The traps were successful as filters for large debris but had limited success as silt-retaining devices. However, erosion occurred around or under many of the traps thus diminishing their effectiveness.

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CONTENTS

| Section | | Page |
|---|---|---|
| I | Conclusions | 1 |
| II | Recommendations | 3 |
| III | Introduction | 5 |
| IV | Materials and Methods | 11 |
| V | Experimental | 19 |
| VI | Discussion | 25 |
| VII | Acknowledgments | 131 |
| VIII | References | 133 |
| IX | Appendices A-D | 135 |

**Preceding page blank**

# FIGURES

Page

1 Map of Lake Madison 6

2 Map of Lake Herman 8

3 Map of Lake Herman Watershed 9

4 A gabion basket. Top view and cross-section of gabion in stream. 17

5 Variation of pH in Lakes Madison and Herman During 1968 29

6 Variation of pH in Lakes Madison and Herman During 1969 30

7 Variation of pH in Lakes Madison and Herman During 1970 31

8 Variation of pH in Lakes Madison and Herman During 1971 32

9 Variation of Alkalinity in Lakes Madison and Herman During 1970 34

10 Variation of Dissolved Oxygen in Lakes Madison and Herman During 1970 35

11 Variation of Silica in Lakes Madison and Herman During 1970 37

12 Variation of Silica in Lakes Madison and Herman During 1971 38

13 Variation of Ortho Phosphate in Lakes Madison and Herman During 1970 39

14 Variation of Total Phosphorus in Lakes Madison and Herman During 1968 41

15 Variation of Total Phosphorus in Lakes Madison and Herman During 1969 42

16 Variation of Total Phosphorus in Lakes Madison and Herman During 1970 43

17 Variation of Total Phosphorus in Lakes Madison and Herman During 1971 44

**Preceding page blank**

Page

18 Variation of Nitrate in Lakes Madison and Herman During 1968 45

19 Variation of Nitrate in Lakes Madison and Herman During 1969 46

20 Variation of Nitrate in Lakes Madison and Herman During 1970 47

21 Variation of Nitrate in Lakes Madison and Herman During 1971 48

22 Variation of pH, Dissolved Oxygen, and Temperature in Lake Herman During 1970 50

23 Variation of Hardness in Lakes Madison and Herman During 1968 51

24 Variation of Hardness in Lakes Madison and Herman During 1969 52

25 Variation of Hardness in Lakes Madison and Herman During 1970 53

26 Variation of Hardness in Lakes Madison and Herman During 1971 54

27 Variation of Magnesium in Lakes Madison and Herman During 1970 55

28 Variation of Magnesium in Lakes Madison and Herman During 1971 56

29 Variation of Magnesium and Ortho Phosphate in Lake Madison During 1970 58

30 Variation of Iron in Lakes Madison and Herman During 1970 59

31 Variation of Iron in Lakes Madison and Herman During 1971 60

32 Variation of Manganese in Lakes Madison and Herman During 1970 61

33 Variation of Manganese in Lakes Madison and Herman During 1971 62

Page

34 Variation of Potassium in Lakes Madison and Herman During 1970 64

35 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1968 66

36 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1969 67

37 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1970 68

38 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1971 69

39 Variations in Population Densities of Planktonic Diatoms in Lake Madison During 1968 70

40 Variations in Population Densities of Planktonic Diatoms in Lake Madison During 1969 71

41 Variations in Population Densities of Planktonic Diatoms in Lake Madison During 1970 72

42 Variations in Population Densities of Planktonic Diatoms in Lake Madison During 1971 73

43 Variations in Population Densities of Total Phytoplankton in Lake Madison During 1968 74

44 Variations in Population Densities of Total Phytoplankton in Lake Madison During 1969 75

45 Variations in Population Densities of Total Phytoplankton in Lake Madison During 1970 76

46 Variations in Population Densities of Total Phytoplankton in Lake Madison During 1971 77

47 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman 1968 79

48 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1968 80

49 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1969 81

Page

50 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1969 82

51 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1970 84

52 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1970 85

53 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1971 86

54 Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1971 87

55 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1968 88

56 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1968 89

57 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1969 90

58 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1969 91

59 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1970 92

60 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1970 93

61 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1971 94

62 Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1971 95

63 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1968 96

64 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1968 97

65 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1969 98

Page

66 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1969 99

67 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1970 100

68 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1970 101

69 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1971 102

70 Variations in Population Densities of Total Phytoplankton in Lake Herman During 1971 103

71 Variations in Population Densities of Copepods in Lake Madison During 1970 106

72 Variations in Population Densities of Cladocerans in Lake Madison During 1970 107

73 Variations in Average (Three Sites) Population Densities of Copepods and Cladocerans in Lake Madison During 1970 108

74 Variations in Population Densities of Copepods in Lake Madison During 1971 109

75 Variations in Population Densities of Cladocerans in Lake Madison During 1971 110

76 Variations in Average (Three Sites) Population Densities of Copepods and Cladocerans in Lake Madison During 1971 111

77 Variations in Population Densities of Copepods in Lake Herman During 1970 113

78 Variations in Population Densities of Copepods in Lake Herman During 1970 114

79 Variation in Population Densities of Cladocerans in Lake Herman During 1970 115

80 Variations in Population Densities of Cladocerans in Lake Herman During 1970 116

Page

81 Variations in Average (Four Sites) Population Densities of Copepods and Cladocerans in Lake Herman During 1970 117

82 Variations in Population Densities of Copepods in Lake Herman During 1971 118

83 Variations in Population Densities of Copepods in Lake Herman During 1971 119

84 Variations in Population Densities of Cladocerans in Lake Herman During 1971 120

85 Variations in Population Densities of Cladocerans in Lake Herman During 1971 121

86 Variations in Average (Four Sites) Population Densities of Copepods and Cladocerans in Lake Herman During 1971 122

87 Silt Trap No. 1 125

88 Silt Trap No. 13 125

89 Silt Trap No. 4 with debris collected along upstream face. 126

90 Silt Trap No. 13 with debris collected along upstream face. 126

91 Silt Trap No. 9 with side erosion (flanking). 127

92 Silt Trap No. 10 with erosion (undercutting). 127

93 Silt Trap No. 16 with upstream and downstream aprons. 128

94 Silt Trap No. 17 with downstream apron. 128

# TABLES

| Number | | Page |
|---|---|---|
| I | Parameters for Metal Analyses by Means of Atomic Absorption Spectroscopy | 14 |
| II | Stock Standards for Metal Analyses | 13 |
| III | Lake Madison Phosphorus Levels at Different Locations | 26 |
| IV | Variation of Nutrients in Lake Herman Tributaries with Time of Year | 28 |
| V | Measurements on Water Above and Below Gabion Silt Traps | 129 |

## SECTION I

## CONCLUSIONS

1. Spring run-offs from the Lake Herman watershed cause large increases in iron, phosphorus and nitrogen in Lake Herman. Since these chemicals are all algae nutrients, they contribute to the summer algal blooms and thus to ensuing winter fish kills.

2. The summer nutrient levels in Lake Herman are directly related to the quantity and quality of the spring run-offs.

3. Successive spring run-offs on the Lake Herman watershed exhibit decreasing levels of phosphorus, nitrogen and iron but increasing levels of alkalinity and dissolved silica.

4. Lake Madison, which has a small watershed but which receives the effluent from a sewage treatment plant, also receives influxes of phosphorus and nitrogen in the early spring.

5. Lake Madison exhibits conductivities twice as high and chloride levels thirty times as high as those in Lake Herman.

6. Gabion silt traps exhibit a limited success as silt retaining devices.

7. The selection of a proper site for the silt trap is of critical importance for its effectiveness. Construction of gabion silt traps in eroded creekbeds and countersinking measures result in erosion around and under the silt trap.

8. Gabion silt traps are effective as filters for coarse debris.

9. During the three-year project, the phytoplankton densities were consistently higher in Lake Madison (a sewage polluted lake) than in Lake Herman (a silt polluted lake).

10. Diatom blooms and blue-green blooms were common during the spring, summer, and fall in both Lake Madison and Lake Herman.

11. The highest densities of the blue-greens and the diatoms were inversely related in both Lake Madison and Lake Herman.

12. The blue-green alga responsible for the major portion of all blue-green blooms in Lake Madison was Aphanizomenon flos-aquae. Phormidium minnesotense was second in abundance of the blue-greens but was sporadic in occurrence. Species of Cyclotella dominated most of the diatom blooms in Lake Madison. Species of Nitzschia and Stephanodiscus were of secondary importance, but dominated some of the lighter blooms.

13. The blue-green alga primarily responsible for the blue-green blooms in Lake Herman was Aphanizomenon flos-aquae. Of secondary importance in the blue-green blooms were species of Anabena and Microcystis. The diatoms responsible for the diatom blooms in Lake Herman varied considerably from year to year and sometimes from bloom to bloom within a year. Species of Cyclotella, Surirella, Melosira, Nitzschia, and Stephanodiscus were primarily responsible for the diatom blooms in Lake Herman.

14. Euglenoids and green algae were not significantly abundant in either Lake Madison or Lake Herman during the summer, fall, and winter months. In Lake Madison, very light blooms of euglenoids and green algae occurred each spring. Slight increases in green algae occurred sporadically in Lake Herman, but these increases were brief and never contributed significantly to algal blooms. Euglenoids were essentially nonexistent in Lake Herman.

## SECTION II

## RECOMMENDATIONS

Since this study has shown that important algal nutrients are added to Lake Herman by the spring run-offs and their accompanying silt loads, it is recommended that (1) conservation methods and proper farming practices be employed across the watershed to reduce the levels of phosphorus, nitrogen, and silt in the run-off water and (2) further investigations be conducted to develop silt retaining devices.

In projects dealing with lake siltation, it is important to know the amount of silt entering the lake. In such projects, it is recommended that devices, such as weirs and periodic sampling machines, be employed for determining the amount of silt being carried down a watershed. From such measurements, an estimate can be made of the amount of soil erosion occurring in the watershed and the amount of silt entering the lake. Only in this manner can the effectiveness of remedial measures be quantitatively evaluated.

Since Lake Madison receives amounts of phosphorus and nitrogen in considerable excess to those required for algal blooms, it is recommended that the sources of these nutrients into the lake be curtailed.

In areas where extensive soil erosion is occurring, the gabion silt trap may be used to some benefit as a secondary corrective measure. If the gabion silt traps are used, it is recommended that (1) they are placed in regions of a watershed where current velocity is low, (2) they not be countersunk in the soil in any manner, (3) they be placed in creekbeds having a good vegetative cover, (4) aprons be constructed to prevent soil erosion around the trap, and (5) they be placed in flat-bottomed creekbeds.

## SECTION III

## INTRODUCTION

In 1966 the biology staff of Dakota State College became interested in studying and comparing two local lakes, one of which was heavily silted and the other of which was relatively free of silt but received the effluent from the local sewage treatment plant. In 1967 and again in 1968 government funds for such a project were applied for, first by Dr. Harold Robinson and then by Dr. Clyde K. Brashier. In the second instance, the application was successful and the grant was renewed for two successive years. The project began June 1, 1968, and was completed May 31, 1971, at a total cost of $64,901, seventy-one percent of which was provided by the Federal Water Quality Administration. The primary objectives of the project were (1) to compare chemical nutrients and biota of a heavily silted lake, Lake Herman, with those of a relatively unsilted, but domestically polluted lake, Lake Madison; and (2) to construct silt traps in the Lake Herman waterways and determine the effectiveness of these silt traps. The biology and chemistry departments of Dakota State College cooperated in this study which was first directed by Dr. Clyde K. Brashier. In February of 1970, Dr. Brashier took a leave of absence from the college and since that time Dr. Constance Churchill, associate professor of chemistry, and Dr. Gordon Leidahl, assistant professor of biology, have directed the study.

Lake Madison lies about three miles southeast of the city of Madison in Lake County, South Dakota. The lake is approximately five miles long and one mile wide and covers about 3200 acres. When full, the lake has an average depth of twelve feet. A map of the lake is shown in Figure 1. The lake bottom is relatively free of silt. Lake Madison is fed by tributaries draining a small watershed mostly in pasture, by springs, and principally by Silver Creek via Bourne's Slough. Silver Creek, in turn, is fed by Lake Herman during the spring and by the city sewage lagoon, one mile above the lake during the entire year. The sewage lagoon receives the effluent from the sewage treatment plant of Madison, a city of about 6,000. This plant was constructed for a city of 5,000-10,000 population and is of the secondary treatment type involving settling ponds and bacterial oxidation with a trickling filter system. Until the summer of 1970, the sewage treatment plant was overloaded by wastes from a meat packing plant dealing mostly in pork products. Lake Madison also receives waste materials from year-around and summer cottages along the lake shore and from nearby feedlots during spring thaws and after heavy rains. From the middle of November to the middle of April, the lake has an ice cover and sometimes there are winter fish kills. For instance, there was a complete fish kill during the 1969-1970 winter. There are heavy algal blooms and sometimes unpleasant odors from the lake during the summer months, particularly July and August.

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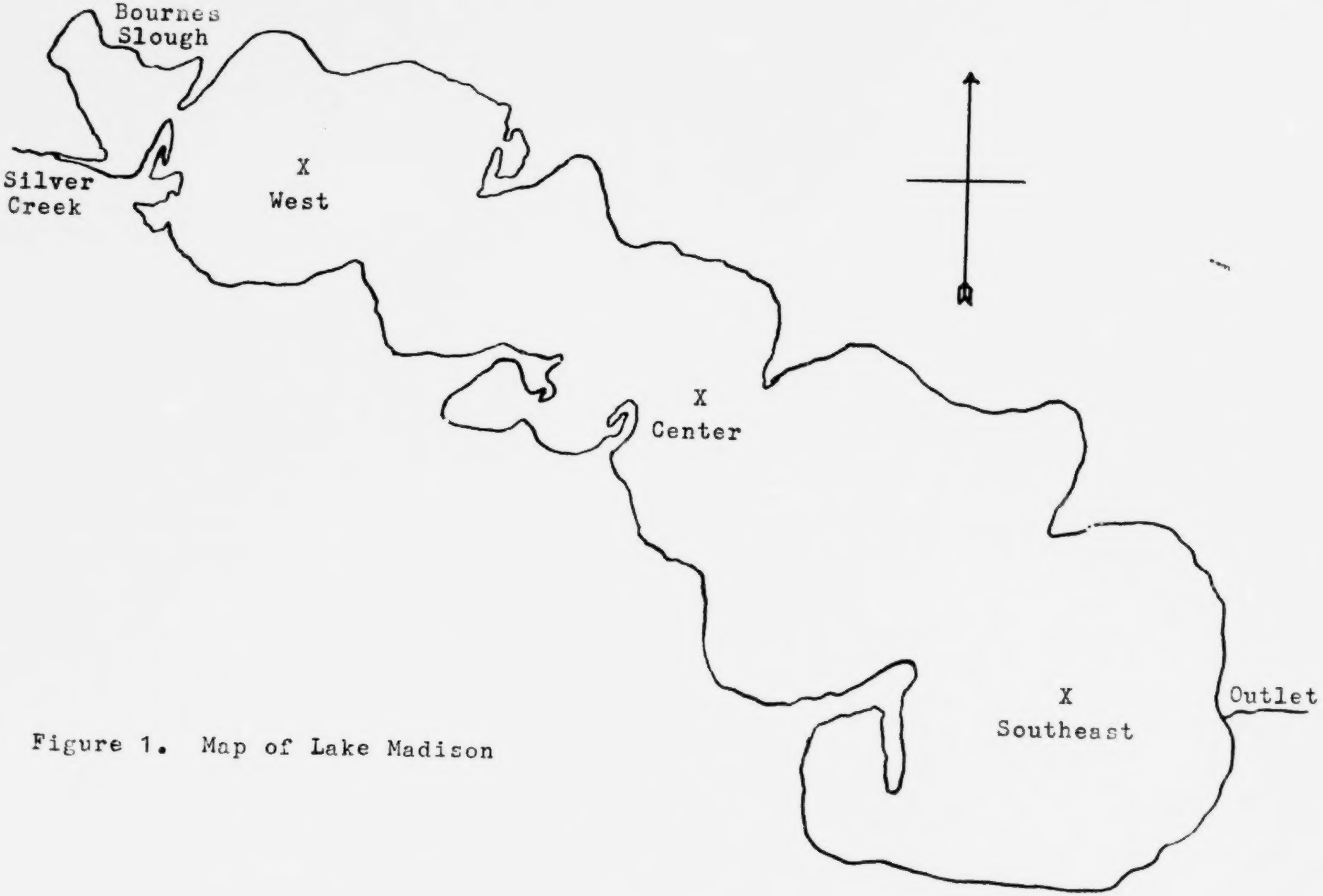
Bournes
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Creek
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West
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Center
X
Southeast
Outlet

Figure 1. Map of Lake Madison

The landowners around Lake Madison have organized into a group called the Lake Madison Development Association. In order to reduce algal blooms and ensuing fish kills, this group has treated the lake with copper sulfate for the past several summers. They have also tried to persuade farmers to move feedlots which drain into the lake and the city of Madison to divert the effluent from the sewage treatment plant. In order to be more persuasive the group has decided it must clean up its own contributions to the pollution. Accordingly, they have formed a sanitation district and are arranging for the construction of a sewage collection system around Lake Madison.

Lake Herman lies four miles southwest of the city of Madison in Lake County, South Dakota. It covers approximately 1,350 acres and, when full, has an average water depth of six and one-half feet. A map of the lake is shown in Figure 2. Lake Herman drains a watershed of fifty-six square miles in which most of the land is cultivated fields of corn and small grains. The watershed has numerous creeks which eventually drain into Lake Herman through three major feeder creeks. A map of the Lake Herman watershed is shown in Figure 3. During the annual spring thaws and after heavy rains, these creeks are swollen with water carrying a heavy silt load. At present, the average silt depth in the lake is six feet. There are very few cabins or homes around the lake, but there is a popular state park on the east shore. From the middle of November to the middle of April, there is an ice cover over the lake and there are frequent winter fish kills. There was a fish kill during the 1968-1969 winter and only an early thaw and coal dusting saved the lake from a fish kill during the 1970-1971 winter. During the remainder of the year the lake is often turbid due to wind and wave action stirring up sediments. Heavy algal blooms occur during the summer.

The college work on Lake Herman and its surrounding watershed, as well as the importance of the lake and the state park in attracting tourists, has provoked extensive civic interest. Farmers on the watershed who employ conservation methods are recognized and civic groups often tour the watershed to examine conservation methods being used and the silt traps built by the college. In addition, a city and county group, the Lake Herman Development Association, began dredging the lake in July of 1970 with the aid of federal, state, county and local funds. The college is investigating the effects of the dredging with a grant from the Office of Water Resources Research.

In order to compare the chemical nutrients and biota of a heavily silted lake with those of a domestically polluted lake, water samples were periodically collected from standard sites on Lake Madison and Lake Herman. The water samples were analyzed quantitatively for a number of chemical parameters and qualitatively and quantitatively for planktonic algae and planktonic crustaceans. In addition, Silver Creek has been periodically monitored at various points for chemical nutrients being carried to Lake Madison, and the creeks in the Lake Herman watershed have been monitored during the spring thaws and after heavy rains for chemical nutrients.

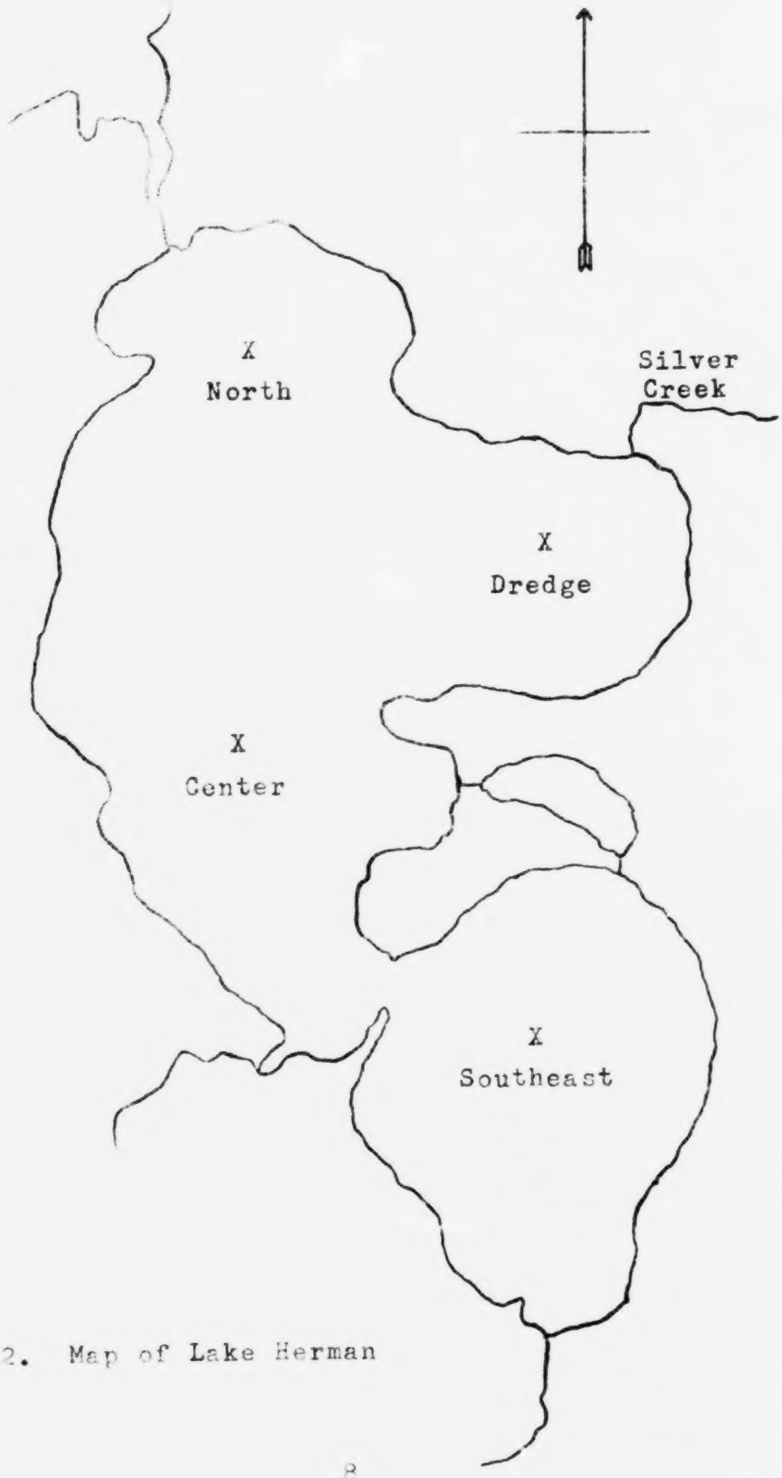
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Figure 2. Map of Lake Herman

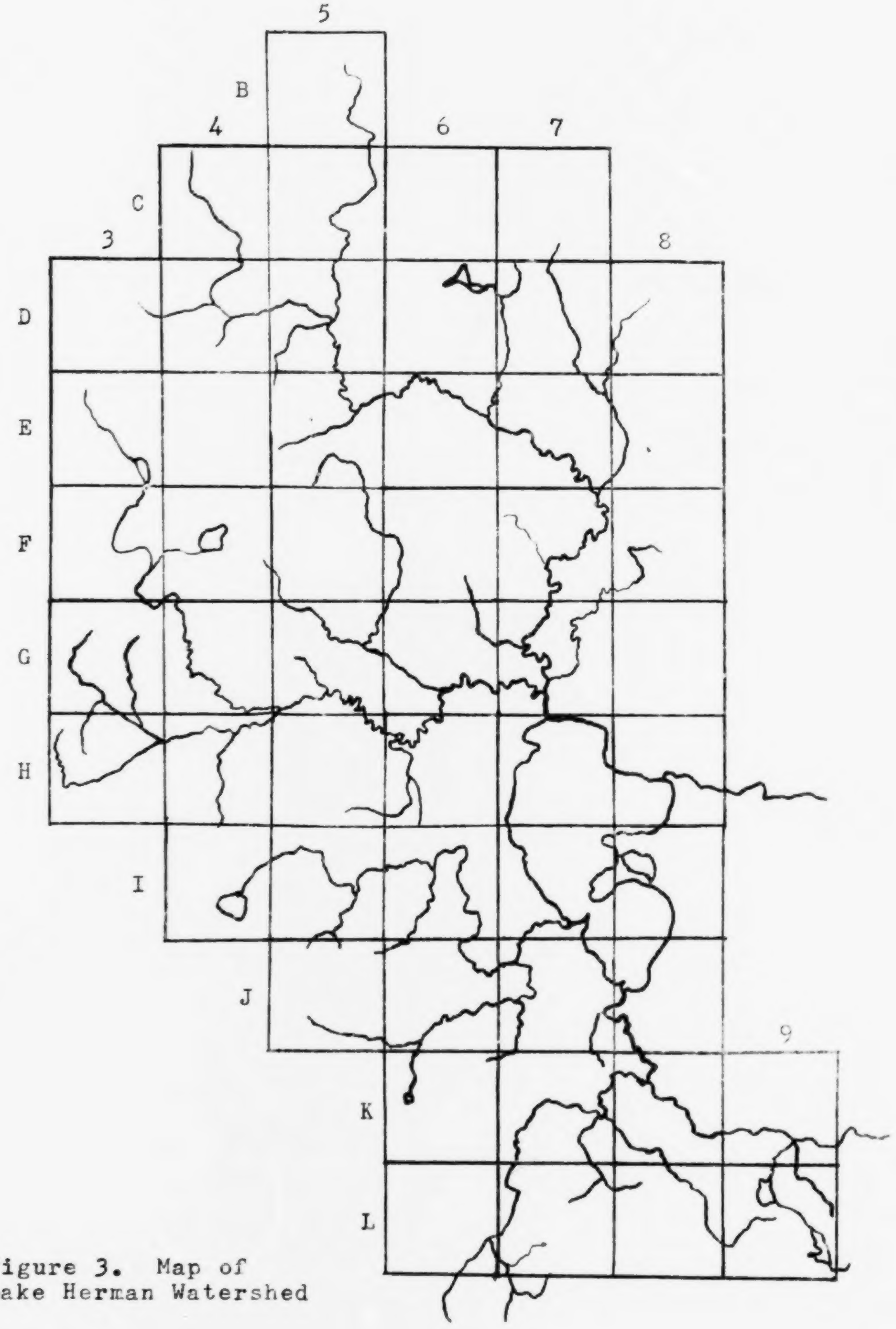
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Figure 3. Map of
Lake Herman Watershed

During the summers of 1969 and 1970, seventeen gabion silt traps were constructed on the Lake Herman creeks. Gabions are individual wire, box-like structures which are filled with rocks, stacked, and wired together to form the silt trap. The traps were of several structural types and were constructed in locations of different creekbeds and water-flow rates in order to evaluate which combinations of design and location were most effective in retarding the silt flow. The traps were examined for effectiveness and possible damage during June of 1970 and 1971. In addition water samples were collected above, between, and below silt traps during heavy run-offs for analyses of chemical nutrients and filtered solids.

## SECTION IV

## MATERIALS AND METHODS

Generally speaking, for the first year of the study, water samples were analyzed chemically by Water and Waste Water Analysis Procedures issued by the Hach Chemical Company and, for the last two years of the study, by the procedures in FWPCA Methods for Chemical Analysis of Water and Wastes, 1967 and 1969. Samples for ammonia, nitrate, nitrite, and silica analysis were collected in plastic containers and immediately preserved with 53-55 mg mercury (II) chloride per liter of water sample. After preservation the samples were refrigerated (0-5° C.) and analyzed from one to twenty-one days later. Samples for metal analysis were collected in plastic containers, filtered through Whatman #40 into 200 ml plastic containers, immediately preserved with twelve drops of 35-36% redistilled nitric acid, and analyzed within six months. Dissolved oxygen samples were collected in glass BOD containers and preserved immediately as described in Water and Waste Water Analysis Procedures. The other analyses were on unpreserved samples collected in plastic containers; the dates of analyses are available. Generally speaking, pH was determined immediately or within two hours of collection; alkalinity within two hours; ortho phosphate, conductivity, turbidity, and dissolved oxygen within six hours; total phosphorus, hardness, and COD within twenty-four hours; chloride and filtered solids within seventy-two hours.

All colorimetric analyses were determined with a Bausch and Lomb Spectronic 20. All metal analyses since January, 1970, were determined with a Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer used in conjunction with a Perkin-Elmer recorder readout and Perkin-Elmer 165 Recorder. Conductivities were determined throughout the project with a Hach Model 2200 Conductivity Meter. Until November of 1969, conductivities were determined in ppm NaCl using the temperature compensator on the meter and without salt standards. Since November, 1969, conductivities have been determined in a constant temperature bath at 25° C. as described in the 1967 FWPCA manual. Turbidities have been determined with a Hellige 160 Turbidimeter and a cell with a viewing depth of ten mm, using the FWPCA recommended procedure. Secchi disk readings were taken with a disk having a diameter of eight inches and divided into quarters with alternating black and white markings.

Alkalinity, dissolved oxygen, COD, chloride and hardness have been determined throughout this project by titrimetric methods. Alkalinity has been analyzed by titration with approximately 0.02N sulfuric acid to a pH of 4.5 as detected with a pH meter. Before September 19, 1969, a 50 ml sample was used; since that time a 100 ml sample has been used as described in the FWPCA method. Dissolved oxygen levels have been determined throughout the project with a modified Winkler method using phenylarsine oxide as the titrant and a starch indicator end point. The procedure is described in the Hach Manual. Chemical oxygen demand (COD) has been analyzed by dichromate oxidation followed by back titration of the excess dichromate with ferrous ammonium sulfate as recommended by FWPCA. Chloride concentrations were determined until August of 1969 by the Mohr Titration procedure described in the Hach manual. Since that time chloride has been analyzed by the mercuric nitrate titration recommended by FWPCA. Total hardness has been determined throughout this project by titration with EDTA using a calmagite indicator as described in the Hach manual.

Concentrations of nitrate, nitrite, silica, ortho phosphate, total phosphorus, ammonia, and potassiums before January, 1970, have been determined by colorimetric methods. Until the end of August, 1969, combined nitrate and nitrite concentrations were determined by reduction of nitrate to nitrite followed by diazotization of sulfanilamide and coupling with an aromatic amine. The procedure used is described in the Hach manual. Since that time nitrate and nitrite concentrations have been determined separately and on samples preserved with mercuric chloride and filtered through Whatman #40. The concentration of nitrite has been determined by essentially the same method described above and recommended by FWPCA. Nitrate levels have been determined through a color reaction with brucine sulfate as described by FWPCA. Silica levels have been determined on samples, preserved with mercuric chloride and filtered through Whatman #40, by means of reaction with ammonium molybdate. Ortho phosphate concentrations have been determined on filtered samples by reaction with ammonium molybdate followed by stannous chloride reduction as described in Standard Methods. Total phosphorus concentrations have been determined on unfiltered samples by boiling 100 ml of sample, or an aliquot diluted to 100 ml, with 1.0 ml of strong acid solution and 0.80 g of potassium persulfate for ninety minutes, neutralizing with aqueous sodium hydroxide to a phenolphthalein end point, and then proceeding as with ortho phosphates. All filtering associated with phosphate analysis was done through Whatman #40 or #42 and a blank of distilled water, treated in every way like the samples, was used to adjust the colorimeter to 100% transmittance. Before January, 1970, potassium concentrations were determined by precipitation with sodium cobaltinitrite followed by oxidation with dichromate and colorimetric determination of the excess dichromate.

Since the beginning of this project, ammonia concentrations have been determined by three different colorimetric methods. Until November, 1969, ammonia levels were determined on unpreserved, filtered samples by direct Nesslerization as described in the Hach manual. From November, 1969, to April 24, 1970, ammonia levels were determined on samples preserved with mercuric chloride, distilled at a pH of 9.5, and Nesslerized as recommended by FWPCA. Since April 24, 1970, ammonia concentrations have been determined by a manual modification of the automated FWPCA method. The solutions were prepared as described for the automated method. Ten milliliter samples, preserved with mercuric chloride and filtered through Whatman #40, a blank, and five standards ranging up to 2 mg/l ammonia-N were simultaneously determined. To each standard, blank, and sample, 4 ml of sodium hydroxide-EDTA were added, followed in rapid succession by 3 ml of sodium phenolate, 3 ml of sodium hypochlorite and 4 ml of sodium nitroprusside solution. Each of these reagents was added in such a manner that the solution was thoroughly mixed. The blank, standards, and samples were then set in a water bath at 35-37° C. for approximately twenty minutes and the color intensities determined at 630 millimicrons. Since April, 1971, mercuric chloride in the amount of 53-55 mg/l has been added to the water used for standards, blanks and dilutions in ammonia determinations.

General analytical procedures for all metal analyses since January, 1970, were obtained from *Analytical Methods for Atomic Absorption Spectrophotometry*. Copper, iron, and manganese determinations have been made by direct aspiration of filtered, acid-preserved samples using the operating conditions listed in Table I. Mixed working standards in the appropriate range were prepared from stock solutions on the day of analysis. Sodium and potassium determinations required dilution of the original samples. Eight mixed, working standards in the range of 20-160 mg/l sodium and 5-40 mg/l potassium were prepared on the day of analysis. The standards and samples were then diluted by a factor of approximately ten with a Model 250 Fisher Diluter. The analyses were carried out using the parameters listed in Table I. Calcium and magnesium samples also required dilution. A blank and eight mixed working standards in the range of 25-200 mg/l calcium and 20-160 mg/l magnesium were prepared from stock solutions on the day of analysis. The standards, samples, and blank were diluted with the Fisher Diluter by a factor of about forty. The diluted samples, standards and blank were discharged from the diluter into 15 x 125 mm test tubes containing 0.5 ml of $LaCl_3$ solution. The $LaCl_3$ reagent was prepared by slowly dissolving 29 g of $La_2O_3$ in 250 ml of concentrated hydrochloric acid and diluting to 500 ml with demineralized distilled water after the hydrochloric acid had cooled. Samples were then analyzed using the parameters in Table I. Reagents used for metal stock solutions and the final concentrations of these stock solutions are given in Table II.

Table II Stock Standards For Metal Analyses

| Metal | Reagent Used | Concentration |
|---|---|---|
| Sodium | NaCl, Primary Standard | 1000 mg $Na^+$/l |
| Potassium | KCl, Primary Standard | 100 mg $K^+$/l |
| Calcium | $CaCO_3$, Primary Standard | 500 gm $Ca^{++}$/l |
| Magnesium | MgO, Reagent | 1000 mg $Mg^{++}$/l |
| Copper | Cu Sheet (100.0%) | 1000 mg $Cu^{++}$/l |
| Iron | Fe Wire (99.95%) | 1000 mg $Fe^{+++}$/l |
| Manganese | $MnCl_2 \cdot 4H_2O$, Reagent | 1000 mg $Mn^{++}$/l |

Planktonic algae samples for quantitative enumeration were collected with a one-liter Kemmerer water sampler. In deep regions of the lakes, two liters of lake water were collected from the upper three feet of the

Table I  Parameters for Metal Analyses by Means of Atomic Absorption Spectroscopy

| | Wavelength | Range | Slit | Burner Rotation | Scale Expansion | Chart Speed | Flame | Filter |
|---|---|---|---|---|---|---|---|---|
| Na | 5890 A | VIS | 4 | 90° | 1X | 20 mm/min | Oxidizing | Out |
| K | 7665 A | VIS | 4 | 0° | 1X | 20 mm/min | Oxidizing | In |
| Ca | 4227 A | VIS | 4 | 0° | 1X | 20 mm/min | Reducing | Out |
| Mg | 2852 A | UV | 5 | 60° | 1X | 20 mm/min | Reducing | Out |
| Cu | 3247 A | UV | 4 | 0° | 10X | 5 mm/min | Oxidizing | Out |
| Fe | 2483 A | UV | 3 | 0° | 10X | 5 mm/min | Oxidizing | Out |
| Mn | 2795 A | UV | 4 | 0° | 10X | 5 mm/min | Oxidizing | Out |

lake, two liters were collected from the middle of the water column, and two liters were collected immediately above a distance of one foot from the lake bottom. In shallow water, two liters of lake water were collected from the upper three feet of the lake and two liters were collected immediately above a distance of one foot from the lake bottom. All of the water samples from one site were placed in a pail and brought into the laboratory. The four or six liters of lake water were gently stirred with a dipper to mix the sample thoroughly prior to concentrating it by column sedimentation (concentration by natural settling out in a cylindrical column). Two one-liter columns (one-liter graduated cylinders) were filled with lake water from a standard site. One hundred milliliters of formalin (40% formaldehyde) were added to each column as a killing and preserving agent. The columns were allowed to stand for two weeks in a dark room. The upper 750 ml of fluid in each column was then removed by means of glass tubing, a plastic hose, and a vacuum pump. The remaining 250 ml in the column was stirred and transferred to a smaller column (500 ml graduated cylinder) where it was mixed with a second 250 ml that had been treated in the same manner and had come from the same site. The column was allowed to stand for two more weeks in a dark room. At this time, the upper 400 ml was removed by vacuum suction as before. The remaining 100 ml sample was stirred thoroughly and transferred to a third sedimentation column (100 ml graduated cylinder) where it was allowed to stand for a third period of two weeks. The upper 80 ml were removed by vacuum suction, and the remaining 20 ml were transferred to a vial. The vial was labeled and sealed with wax until the sample could be counted. The samples were stored in a dark cabinet at room temperature. The planktonic algae were later enumerated to genus or species using a Sedgwick-Rafter counting chamber and a compound microscope with a magnification of 100X. Twenty fields of view were counted at twenty evenly spaced, predetermined locations on the counting chamber.

Algal samples for qualitative enumeration were collected using a standard plankton towing with a No. 25 standard silk bolting cloth. They were preserved in a preservative composed of six parts of water, three parts of 95% alcohol, and one part of commercial formalin. Five milliliters of glycerin was added to each 100 ml of preservative to protect the samples against loss from preservative evaporation.

Planktonic copepods and cladocerans were collected with a five-liter Juday plankton trap. The samples were preserved with 70% alcohol and were later reduced to a volume of twenty milliliters by column sedimentation. Five milliliters of each concentrated sample were counted using a five milliliter counting chamber of the Sedgwick-Rafter type and a compound microscope. Magnifications of 40X and 100X were used to count the copepods and cladocerans and to identify them to genus and species.

One objective of this project was to devise relatively simple and inexpensive silt traps that could be periodically desilted. Because of low cost, flexibility, durability, and permeability features, gabion baskets (or simply gabions) manufactured by Maccaferri Gabions of

America, Inc. (55 West 42nd Street, New York) were selected as a basic building material. The gabions are rectangular, wire mesh baskets (see Figure 4) which are filled with rocks and wired shut. They are manufactured in sizes ranging from approximately six to thirteen feet long and from approximately one to three feet high, but they can be wired together in series and used as "building blocks" to form various sizes and shapes of stream improvement structures. Maccaferri gabions have been used to construct weirs, groins, groynes, retaining walls, revetments, channel lining and other such structures.

The gabions were shipped as unassembled, one piece units. They were taken as such to the chosen site, unfolded, flattened, and stretched to remove all kinks. The creases were arranged in the proper positions for forming the box, and the side and end panels were folded into a vertical position. The vertical edges were then joined at six inch intervals with wire ties. When more than one gabion cell was present in a unit, the diaphragm panels (partitions which formed the serial gabion cells) were raised and fixed in the same manner. The heavy-gage selvage wire at the top corner of each gabion was bent around the top mesh of the adjoining sides. Thus, a rectangular box with an open lid was formed. The gabions were then placed in position on a smooth, leveled surface and adjacent gabions were fastened along each selvage. The gabions were filled with rocks of five to twelve inches in diameter. For the higher gabions, connecting wires between the sides and ends were placed across every 9-12 inches of gabion height in order to maintain a rectangular shape. For instance, with the eighteen inch high gabions, the basket was filled to half of its height and two connecting wires running lengthwise and two running widthwise were tied in, and then the basket was filled. After all gabions in a trap had been wired together and filled, the lid of each was folded into place. Each lid was secured with lacing wire or with ties placed at six inch intervals along all edges and diaphragms.

A construction crew of three to five individuals was employed during the summers of 1969 and 1970 to build the silt traps. Rocks were obtained from an abandoned gravel pit by means of manual labor and a tractor with a hydraulic, front-end loader. A dump truck was used to convey the rocks to construction sites which were seven to ten miles away. At the construction sites, a second tractor with a hydraulic, front-end loader was used to unload the rocks. At times the tractor could be used to deposit the rocks directly into the gabions, but manual labor often had to be used.

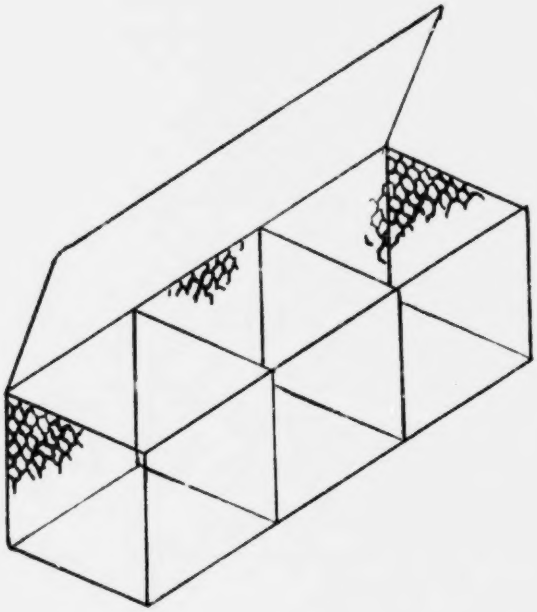
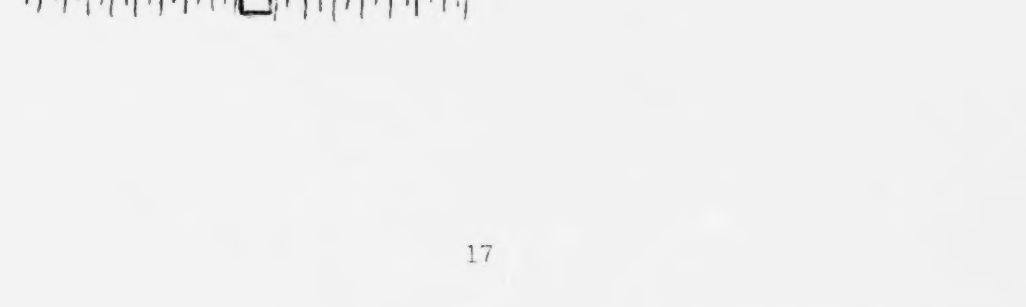


Figure 4. Top: A gabion basket, Bottom: Top view and cross-section of gabion in stream. (Taken from brochure by Maccaferri Gabions of American, Inc.)



## SECTION V

## EXPERIMENTAL

Lake Madison water samples for chemical analyses were collected from three standard sites. These sites are referred to as West, Center, and Southeast and are shown in Figure 1. All reported analyses are from surface samples; during the winter of 1969-1970 some bottom samples were collected in Lake Madison, but these showed no significant variation from the surface samples in nutrient levels. Samples were collected approximately every week during the summer, every two weeks during the spring and fall (or as the ice break-up or formation permitted), and once a month during the winter. Lake Madison samples were generally collected in the late morning or early afternoon; the collection time for each sample is available. The results of the chemical analyses of Lake Madison water are listed in Appendix A. Note that there are two parts of Appendix A, the first listing pH through nitrite values and the second listing temperature through potassium values. During the three years of this project water samples were collected irregularly from Bourne's Slough, the sewage lagoon, various sites along Silver Creek, and other Madison tributaries after heavy rains. The results of the chemical analyses of these samples are listed in Appendix B, which is also in two parts.

Lake Herman water samples for chemical and biological analyses were collected from one to three standard sites during the first half of this project and from four standard sites during the last half of this project. These sites are referred to as North, Center, Dredge, and Southeast and are shown in Figure 2. All samples were surface samples and were generally collected in the middle of the afternoon; the time of each sample collection is available. The results of the chemical analyses of Lake Herman water are listed in Appendix C, which is in two parts.

Water samples were also collected at the major Lake Herman inlets and outlet and randomly across the watershed area during spring thaws and after heavy rains. Some of the results of chemical analyses of these Lake Herman tributary samples are listed in Table IV. The locations are keyed to the Lake Herman watershed map shown in Figure 3. The capital letters divide the watershed horizontally into one mile sections. The numerals divide the area vertically into one mile sections. The first small letter divides a section horizontally into quarter mile parts and the second small letter divides a section vertically into quarter mile parts.

Some core samples were collected from the bottom of Lake Herman during 1969 and 1970. These cores were sent to Arnold Gahler of the FWQA Pacific Northwest Water Laboratory in Corvallis, Oregon. Under his direction the interstitial water and sediment of these cores were chemically analyzed. The results of these analyses are available from the authors. South Dakota State University at Brookings, South Dakota in cooperation with the USDA maintains a research farm two miles north and one mile east of Lake Herman. The personnel of the research farm maintain records of area temperatures and precipitation. This information for the term of this project is also available from the authors.

The water samples which were collected from Lakes Madison and Herman were taken at the same times and locations as the samples for chemical analysis. Lake Madison samples were collected from three standard sites throughout the three-year project. One site was selected at each end of the lake, and one site was selected near the middle of the lake. These sites have been designated West, Center, and Southeast and are shown in Figure 1. The West site is near the major inlet of the lake (Silver Creek via Bourne's Slough), and the Southeast site is near the only outlet of the lake. Lake Herman samples were collected from one to three standard sites during the first half of this project and from four standard sites during the last half of this project. One site is in the southeast extension of the lake which is connected to the main portion of the lake by a narrow but relatively deep channel. A second site is located near the middle of the lake. A third site is at the north end of the lake near the largest inlet of the lake. A fourth site is in the east bay of the lake near the only outlet. Dredging was begun in this bay during the summer of 1970. These seven standard sites were chosen so that the nature of chemical nutrients entering the lakes and their subsequent effects upon the biota of the lakes could be determined. Samples were collected every week during the summer, every second week during the spring and fall, and approximately every fourth week during the winter.

Some of the results of the biological analyses of Lakes Madison and Herman are presented in figures in the discussion section of this report. Complete tables listing population densities for various species of green alga, euglenoid alga, diatoms, and blue-green alga are available from the authors.

Also available from the authors are tables containing the population densities of copepods and cladocerans for Lakes Madison and Herman, respectively, during 1970 and 1971. The population densities are listed for the adults of each species of copepod and cladoceran, larval copepods, total copepods, total cladocerans, and total copepods and cladocerans. Also the average population density of copepods and the average population density of cladocerans for the sites of each lake has been calculated for each collection date.

During the summer of 1969, fourteen gabion silt traps were constructed on two major creeks of the Lake Herman watershed. The design, location, nature of the creek, and nature of the surrounding area of each trap is described in detail in Appendix D. These fourteen traps are designated as Traps No. 1-14 in this report. Basically, the fourteen traps are single, vertical walls of rock-filled gabions. Most of them are in eroded creekbeds, and all of them are surrounded by uncultivated land although several are near cultivated fields. The traps are three-eighths to two and one-fourth miles from Lake Herman.

Examination of the traps during and after the spring and early summer run-offs of 1970 revealed that several problems existed in the design of the traps and in the choice of their location. Erosion of soil around the silt traps was the major problem. Traps No. 10, 11, and 14 were damaged by the removal of soil under them (undercutting), and Traps No. 8, 9, 10 and 11 were damaged by the removal of soil at their sides (flanking). Soil erosion was particularly great in two traps (No. 8 and 11) that were built in creek bends and in one of the larger traps (No. 14) that was built in an area receiving a large volume of water. Note below that most soil erosion occurred where part of a trap was countersunk in a creek bank. Silt Trap No. 8 was damaged by soil erosion at the end of its main section where it was countersunk about one-half foot in the creek bank. The hole was three feet wide and two feet and four inches deep. Silt Trap No. 9 was similarly damaged by soil erosion at the end of its main section where it was countersunk about one foot in the creek bank. The hole was three and one-half feet wide and one foot and eight inches deep. A second hold, which was two feet wide and nine inches deep, was eroded under the trap where the wing and main section meet. The erosion occurred where the main section was countersunk about one foot in the creek bank. Silt Trap No. 10 was damaged by soil erosion which caused two holes each of which was approximately two and one-half feet wide and one and one-half feet deep. A hole was formed at each end of the main section, where the end was countersunk about one-half foot in the creek bank, and under the adjacent portion of each wing. Silt Trap No. 11 was damaged by soil erosion at one end of its main section, where it was countersunk about one-half foot in the creek bank, and under the adjacent portion of the wing. The hole was two and one-half feet wide and one and one-half feet deep. Silt Trap No. 14 was damaged by soil erosion under the middle of the trap. The hole was seven feet wide and two feet deep and was in the middle of the creekbed. The gabions over the hole dropped about one foot into the hole. Soil erosion also occurred in the middle of the creekbed immediately upstream from the trap. The hole was approximately ten feet long, three feet wide, and one and one-half feet deep.

Difficulty was also encountered in determining how long the silt traps had to be to prevent water from flowing around their ends. Water was backed up behind Traps No. 3, 4, 7, 8, 10, 11 and 12 to the extent that it flowed around the traps. Because the ends of these traps were on sodded soil, no erosion occurred, but the effectiveness of the traps was undoubtedly reduced.

The two largest silt traps had yet another problem. Water spilling over the central portions of Traps No. 13 and 14 caused the removal of soil where it fell on the downstream side. Probably all of the fourteen traps are not high enough to prevent water from flowing over portions of them after heavy rainfall or heavy snow melts. Under such conditions, the effectiveness of the traps is reduced. This was noted especially to be a problem of Traps No. 2, 11, 12, 13, and 14.

During the summer of 1970, three gabion silt traps (No. 15, 16 and 17) were constructed, and some of the damaged traps (No. 10, 11 and 14) were repaired. The design, location, nature of the creek, and nature of the surrounding area of each of the new traps is described in detail in Appendix D. The nature of the creeks, the nature of the surrounding area, and some of the design features are different than those of the traps built in 1969. None of the traps are in an eroded creekbed, and one trap is immediately below a cultivated field. The traps are 375 feet to two and one-half miles from Lake Herman.

Several changes were made in the design of the silt traps. Extensions (aprons) of the traps' bases were constructed to slow water movement through the lower portions of the traps and thus prevent or reduce soil erosion. The aprons of two traps (No. 15 and 16) are two series of gabions that are each one foot high and three feet and three inches wide. The aprons extend for six feet and six inches both upstream and downstream and extend either the entire length of the trap or across most of the middle portion. A third trap (No. 17) was built that has no apron on the upstream side but has two "step-down" aprons on the downstream side. The first "step-down" apron consists of gabions eighteen inches high and three feet and three inches wide. Immediately downstream from it there is a second apron consisting of gabions one foot high and three feet and three inches wide. Small rocks about 5 to 6 inches in diameter were placed in the aprons and in the bases of the vertical walls of these three silt traps. One half of the bottom of Trap No. 15 was covered with plastic screen.

To help prevent soil erosion around the silt traps, Traps No. 15, 16 and 17 were built in well-sodded creekbeds which have well-defined ravines surrounding them. The traps extend entirely across the creeks and far enough up the surrounding ravines that water will not flow around the traps under any circumstances. Only flat-bottomed creekbeds that merge imperceptibly with the surrounding ravines were chosen as sites for the silt traps.

Measures that could be taken to repair the damaged silt traps were quite limited owing to their bulk and weight. Primarily, repair measures consisted of packing rocks into the holes around the traps (Traps No. 10, 11 and 14) and constructing aprons both upstream and downstream (Traps No. 13 and 14). The aprons were similar to those of Traps No. 15 and 16 except that gabions were not used and the rocks were placed only along the middle portions of the traps. Approximately one foot of rocks was piled upstream and downstream for distances of five feet to ten feet from the vertical walls to form the aprons. Traps No. 10 and 11 had a layer of rocks about one foot wide and one foot high placed along their upstream junctions with their creekbeds. No corrective measures were attempted for traps that had water flowing around their ends. Elaborate reconstruction would have been necessary to solve most of the problems of this type.

Examination of the traps during June of 1971 revealed that the erosion of soil around some of the traps was still a problem. Silt Traps No. 10 and 11 had further erosion in the same places as the previous year. Approximately ten inches of soil had been eroded around the rocks which had been used to repair the traps. Silt Trap No. 13, which had not been damaged during the first year following construction, had a single hole about twelve feet from the middle of the trap. The hole was not in the creekbed as in the cases of the other traps, but was on well-sodded soil at the bottom of the ravine and to one side of the creek. The hole was two feet and two inches wide and one foot and four inches deep. Silt Trap No. 14 was damaged once again by soil erosion under the middle of the trap. Soil from an area fifteen feet wide and one foot deep was eroded between July of 1970 and June of 1971. The gabions have dropped into the hole to nearly fill it.

During the summer of 1971. the silt traps were examined to determine the amounts of silt deposited behind them. Steel rods, which had been driven in the ground immediately behind the traps when they were constructed, served as markers for determining the amount of silt present. Silt deposits ranging from one-half inch to three inches in depth were found behind six of the traps. Silt Traps No. 1, 2, 3, 7, 9 and 12 had 2. ½, 1½, 2, 2½, and 3 inches of silt behind them respectively. No silt was found behind Traps No. 4. 5, 6, 8, 10. 11. 13, 14, 15, 16 and 17. However, the upstream side of nearly all of the traps had been densely covered with roots, grasses, and pieces of wood.

During the spring run-offs of 1970 and 1971 water samples were collected some distance above, just above, between and below silt traps. The results and significance of these analyses are discussed in the next section.

## SECTION VI

## DISCUSSION

The chemical results listed in Appendices A-C show certain variations as to location and season of the year. There are also interesting differences between the two lakes which stem from the fact that one is polluted from siltation and the other is polluted from domestic wastes. These results are discussed below as to (1) differences due to location in Lake Madison, in Lake Madison tributaries, in Lake Herman, and in Lake Herman tributaries; (2) differences due to time of the year; and (3) a comparison of each measured chemical parameter between the two lakes.

The general flow of water in Lake Madison is from the west to the southeast. An examination of the chemical data on Lake Madison water with respect to location (see Appendix A) indicates little change in most nutrient levels from one end of the lake to the other. Such results would indicate that, either no significant quantity of nutrients was lost to the atmosphere, sediments, and living organisms with movement of water from the inlet to the outlet, or that other sources around the lake replenished whatever was lost. Exceptions to this lack of variation in nutrient level with location are the phosphorus levels, both ortho and total. There is a consistent gradual decrease in phosphorus levels from the west end to the southeast end until the spring of 1970. Some values from Appendix A which illustrate this trend are listed in Table III. Since March of 1970 the phosphorus levels have been uniform over the lake or at least have not varied in a systematic manner. This change to uniform phosphate levels could have been brought about by either an increase in the supply from around the lake or a decrease in the loss from inlet to outlet. Since there has been a gradual decrease of phosphate in Lake Madison during the three years of this project (see Figures 14-17), it would seem that a decrease in loss of phosphate from inlet to outlet would be more reasonable. A possible reason for this decrease in phosphate loss from the lake could be a change in the level of phosphate entering from Bourne's Slough from a level high enough to bring about precipitation and settling to a level relatively stable in lake water. Possibly the slow down of production during the spring of 1970 and closing in July, 1970, of the local meat packing plant which overloaded the sewage treatment facility has influenced the change.

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Table III Lake Madison Phosphorus Levels at Different Locations

| Date | Ortho Phosphate $mgPO_4/l$ West | Ortho Phosphate $mgPO_4/l$ Center | Ortho Phosphate $mgPO_4/l$ Southeast | Total Phosphorus $mgPO_4/l$ West | Total Phosphorus $mgPO_4/l$ Center | Total Phosphorus $mgPO_4/l$ Southeast |
|---|---|---|---|---|---|---|
| July 29, 1969 | | | | 0.40 | 0.35 | 0.32 |
| Aug. 26, 1969 | | | | 0.68 | 0.43 | 0.40 |
| Sept. 27, 1969 | | | | 0.60 | 0.58 | 0.50 |
| Oct. 26, 1969 | 0.11 | 0.07 | 0.05 | 0.81 | 0.45 | 0.34 |
| Jan. 14, 1970 | 0.67 | 0.43 | 0.34 | 0.72 | 0.48 | 0.34 |
| Feb. 14, 1970 | 0.81 | 0.56 | 0.52 | 0.92 | 0.65 | 0.57 |

An examination of the chemical analytical results on Lake Madison tributaries (see Appendix B) indicates a gradual decrease of most nutrient levels from the treated sewage to the sewage lagoon to Silver Creek at the lagoon to Silver Creek below the lagoon to Bourne's Slough. This decrease is not unexpected—undoubtedly many nutrients are lost to the support of living organisms along the way. It would also be expected that some phosphorus would be lost to the sediments and some nitrogen to the atmosphere in the form of nitrogen gas and ammonia. The two parameters which do not follow this generally decreasing trend are pH and dissolved oxygen, both of which tend to increase from treated sewage to Bourne's Slough. In both cases, this increase is undoubtedly related to the extensive plant growth, algae, etc., between the two points.

Lake Herman receives nutrients from three main feeder streams entering the lake at different locations. Furthermore, the lake is often stirred by wind and wave action. These factors would lead one to expect rather uniform nutrient levels over the lake. An examination of the chemical analytical results of Lake Herman water listed in Appendix C does indeed indicate very little difference and no systematic differences in nutrient levels with location in Lake Herman during the first two years of this project. However, since early summer of 1970 the Southeast Bay of Lake Herman has exhibited chemical nutrient levels inconsistent with the remainder of the lake. As the map of Lake Herman, shown in Figure 2 indicates, the Southeast Bay is joined to the remainder of the lake by a rather narrow opening. During the early summer of 1970, plants grew up from the bottom of the lake at this opening and have served to retard water flow between the two parts. An examination of the chemical analytical results on the samples taken from the Lake Herman tributaries indicates no regular differences in nutrient levels from one place on the watershed to another. All three of the major feeder streams carry particularly high levels of phosphorus and nitrogen into the lake.

Both Lake Madison and Lake Herman follow the same seasonal trends in nutrient levels. In very general terms, phosphorus, nitrogen and iron increase at the time of the spring thaw and then rapidly decrease during the late spring and early summer. Most other nutrients, however, exhibit an opposite trend—decreasing sharply at the time of the spring thaw, rising close to normal levels by early summer and then rising very slowly through the fall and winter to the next spring thaw. These variations are borne out on the basis of the chemical data on the two lakes and would also be expected after an examination of the chemical data on the Lake Herman tributaries at the time of the spring thaw. The latter have much higher levels of phosphorus, nitrogen, and iron than the lake water but lower levels of most other nutrients.

An examination of the chemical data on the Lake Herman tributaries at different times of the year indicates some interesting variations. Table IV lists this data. The sites listed are near the three major inlets and are keyed to the map shown in Figure 3. From these data it is apparent that during the late winter and early spring of 1970 and 1971 the levels of ortho phosphate, total phosphorus, ammonia, nitrate, and nitrite decreased with each successive run-off. On the other hand, the alkalinity and silica levels increased with each successive run-off. The increase in alkalinity and silica is probably related to an increase in surface temperature as the season progressed. Generally, hardness, conductivity and pH also increased with successive early run-offs. Iron concerntrations were not determined during the early run-off of 1970 but showed increases during 1971 successive run-offs. Manganese decreased during successive run-offs of 1970 but increased in 1971. In later run-offs occurring during the summer, the above patterns were not followed.

Insufficient Lake Madison tributary samples were collected to allow any general conclusions regarding seasonal variation in chemical nutrient levels in these tributaries.

The pH of Lake Madison and Lake Herman has generally ranged from 7.5 to 9.5. Figures 5-8 depict how the pH in both lakes has varied during the three years of this project. The data depicted is from Appendices A and C; all Lake Madison values for a particular date are averaged as are those for Lake Herman except the southeast sample from April of 1970 to May, 1971. During this period, the southeast Herman pH, being somewhat different than that of the remainder of the lake, is graphed separately. It can be seen from these graphs that in both lakes the pH drops to its lowest annual value during the spring thaw, rises during the summer and gradually falls off during the autumn. The summer rise is accompanied by irregular jumps which generally coincide in the two lakes. The summer rise is undoubtedly related to heavy algal populations. The pH, on the other hand, by restricting the amount of free carbon dioxide in the lake water, would influence the species of algae which can thrive. In both lakes the pH tends to reach a maximum in July or August. It is interesting that Lake Herman has had a higher pH than Lake Madison except during the year after the large spring run-off of 1969. There was a record snow fall during the winter of 1968-1969 and an ensuing particularly heavy spring run-off. Apparently, Lake Herman, being a smaller lake and having a much larger watershed, experienced the effects of the run-off more than Lake Madison.

Table IV Variation of Nutrients in Lake Herman Tributaries with Time of Year

| | Alkalinity mg $CaCO_3$/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3^-N$/1 | Nitrate mg $NO_3^-N$/1 | Nitrite µg $NO_2^-N$/1 |
|---|---|---|---|---|---|---|---|
| Mar. 3, 1970 | | | | | | | |
| G7ca | 49.6 | 7.78 | 2.14 | 3.97 | | 1.46 | 151.7 |
| I7dc | 40.7 | 8.02 | 1.25 | 2.15 | | 1.18 | 111.7 |
| J8ca | 46.1 | 7.26 | 1.46 | 3.04 | | 1.44 | 139.8 |
| Apr. 4, 1970 | | | | | | | |
| G7a | 68.2 | 9.7 | 1.13 | 1.48 | 0.61 | 1.07 | 69.1 |
| I7dc | 47.6 | 8.7 | 0.67 | 1.73 | 0.68 | 0.76 | 104.8 |
| J8ca | 58.4 | 9.3 | 0.50 | 1.59 | 0.64 | 1.20 | 93.8 |
| Apr. 23, 1970 | | | | | | | |
| G7ca | 117 | 18.6 | 0.01 | 0.11 | 0.195 | 0.125 | 3.4 |
| I7dc | 123 | 15.9 | 0.14 | 0.33 | 0.22 | 0.608 | 8.1 |
| J8ba | 126 | 10.6 | 0.13 | 0.66 | 0.00 | 0.780 | 6.4 |
| Feb. 17, 1971 | | | | | | | |
| G7ab | 62.4 | 2.3 | 3.34 | 6.29 | 4.14 | 1.225 | 78.1 |
| I7dc | 36.5 | 3.5 | 1.61 | 1.86 | 0.31 | 1.230 | 44.9 |
| J8ca | 46.7 | 3.3 | 1.15 | 2.63 | 1.68 | 0.600 | 63.4 |
| Mar. 11, 1971 | | | | | | | |
| G7ab | 50.2 | 2.6 | 1.17 | 2.94 | 1.05 | 0.645 | 71.8 |
| J8ca | 50.8 | 2.7 | 0.71 | 1.60 | 0.61 | 0.575 | 68.9 |
| Mar. 29, 1971 | | | | | | | |
| I7dc | 47.4 | 10.0 | 0.56 | | 0.11 | | 74.0 |
| J8ca | 61.9 | 12.2 | 0.63 | | 0.11 | | 85.0 |

Figure 5. Variation of pH in Lakes Madison and Herman During 1968.

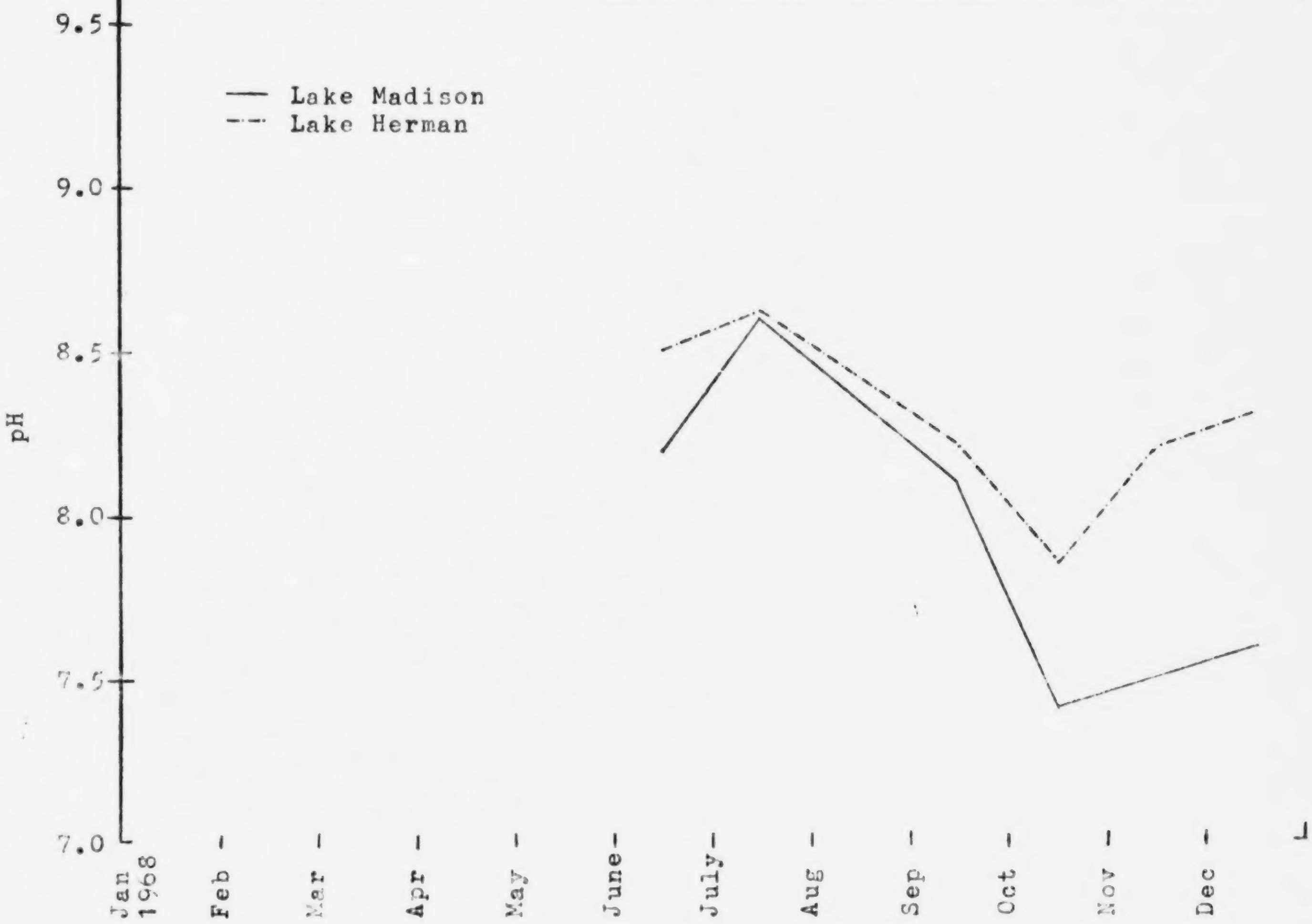


Figure 6. Variation of pH in Lakes Madison and Herman During 1969.

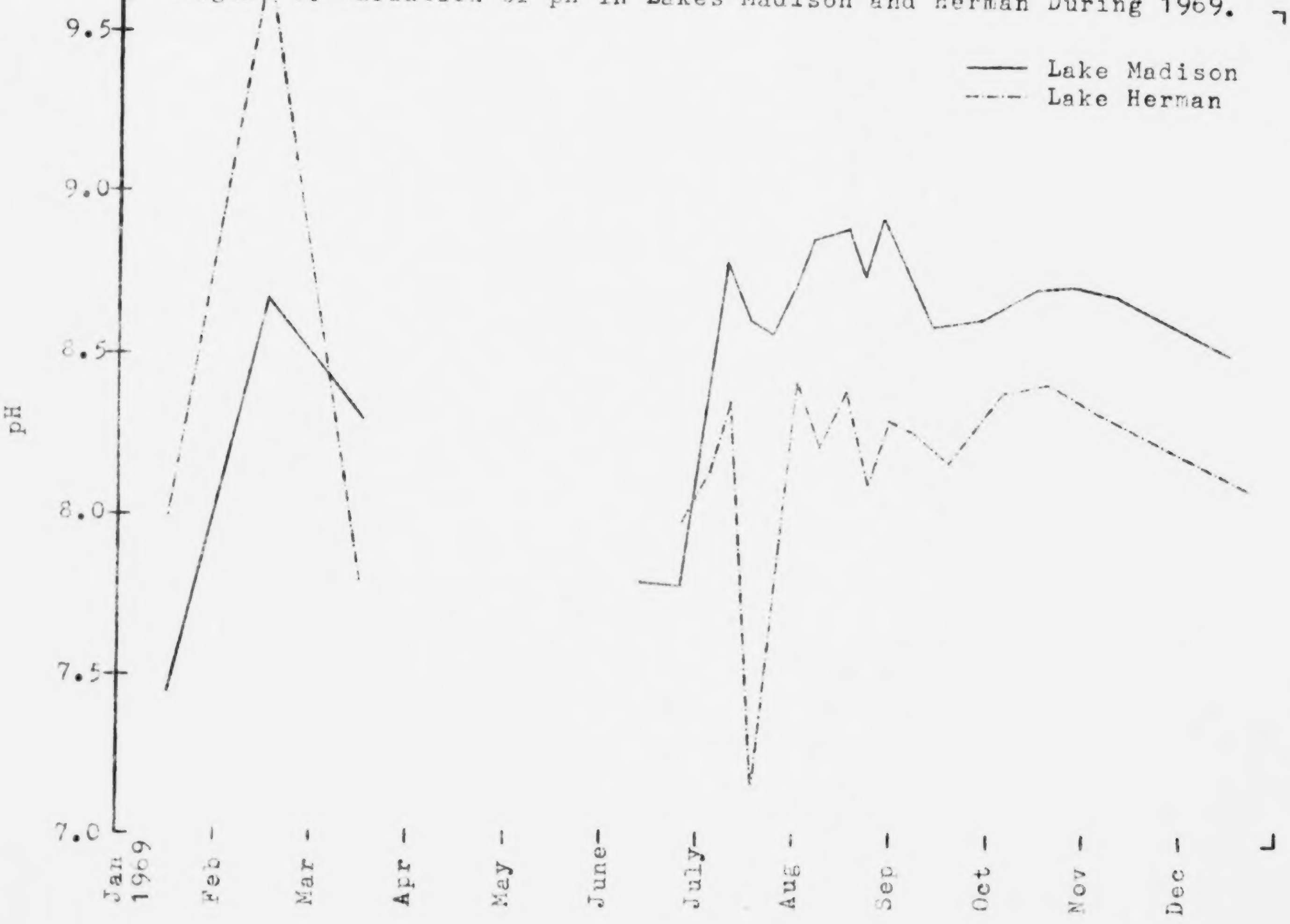


Figure 7. Variation of pH in Lakes Madison and Herman During 1970.

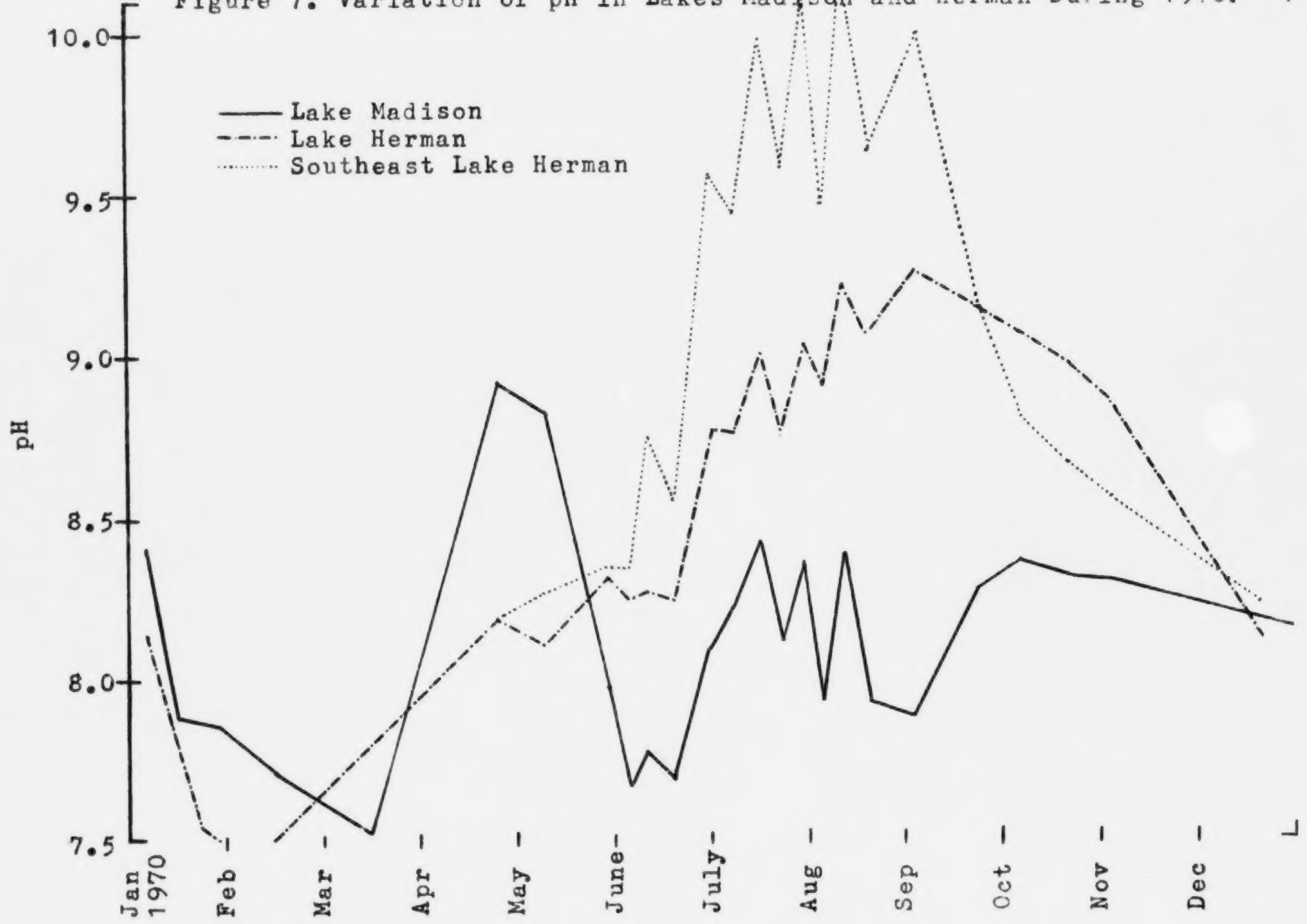
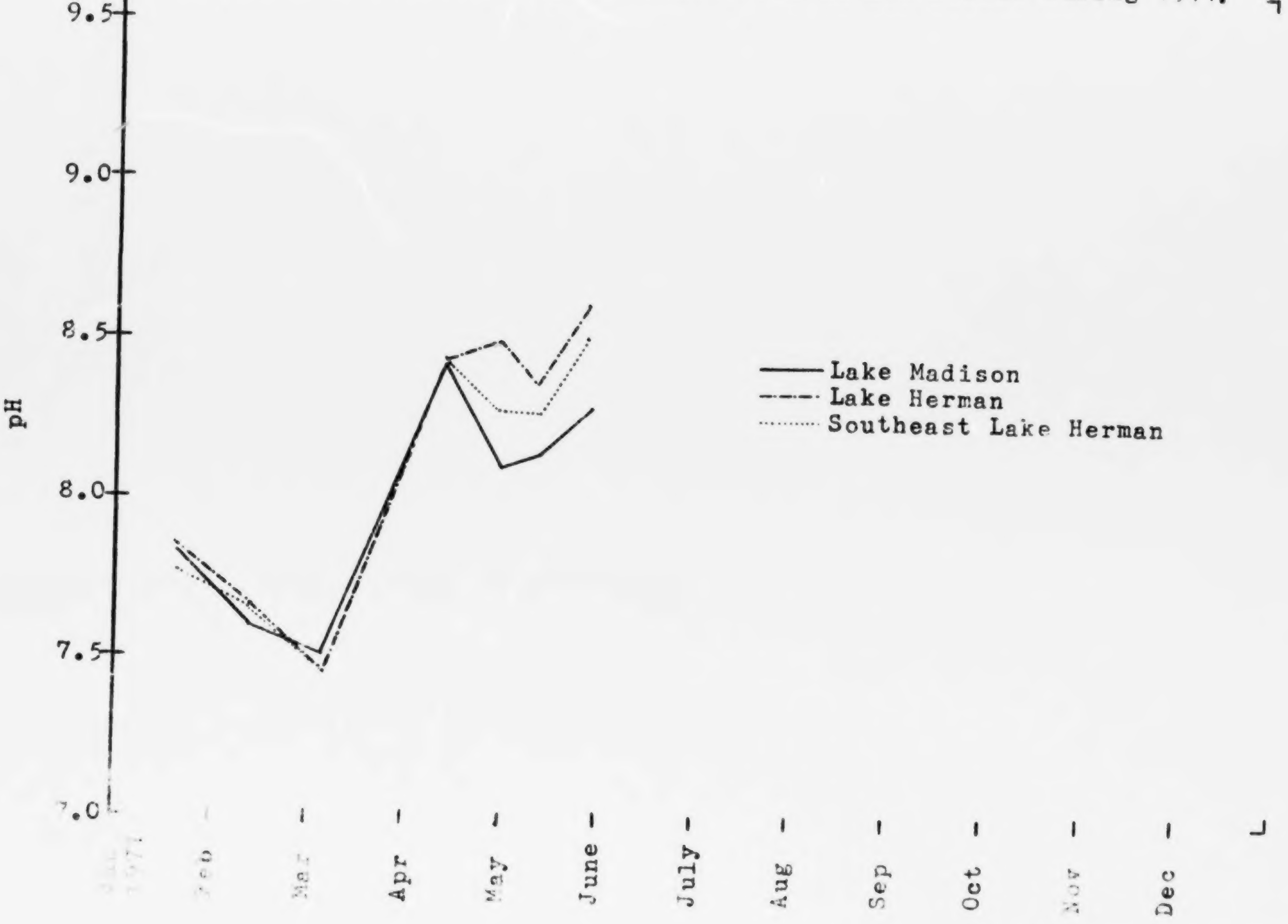


Figure 8. Variation of pH in Lakes Madison and Herman During 1971.



The alkalinity of Lake Madison and Lake Herman has generally ranged from 100-250 mg/l $CaCO_3$. Figure 9 shows the seasonal variation of alkalinity in both lakes during 1970. The data graphed is taken from Appendices A and C; the values for each lake represent averages. Since the summer of 1970 the alkalinity level in Southeast Lake Herman has been quite different than that in the remainder of the lake, and it is graphed separately. Figure 9 represents a rather typical year and, as can be seen, the alkalinity levels in both lakes reach a minimum at the time of the spring run-off, rise rapidly during the spring, remain fairly level or drop slightly during the summer, rise slowly during the autumn and more rapidly after the ice freeze. Both lakes follow the same general trend but Lake Herman experiences changes to a greater degree than Lake Madison. The sharp drop in the alkalinity of Southeast Lake Herman during the summer of 1970 is probably related to heavy plant growth.

Dissolved oxygen levels in both Lake Madison and Lake Herman range from near zero to fifteen parts per million. Figure 10 shows the changes in dissolved oxygen in the two lakes during 1970. The data graphed represent averages of the results listed in Appendices A and C. Typically, dissolved oxygen levels are at a minimum during the winter, rise sharply during the spring, fluctuate widely during the summer and level off in the fall. The low dissolved oxygen level in Lake Herman during February of 1970 corresponds to a fish kill. There was a corresponding low in Lake Madison during February of 1969, which was also accompanied by a fish kill. The wide fluctuations in dissolved oxygen levels during the summer undoubtedly correspond to changes in plant growth. However, the fact that these fluctuations coincide in the two lakes would suggest some other more basic factor which the lakes would have in common, perhaps temperature.

Measurements of chemical oxygen demand (COD) have been made only during the last year of this project. On the basis of that data, both lakes seem to follow the same general trend, a slight rise at the time of the spring run-off, a decrease to an annual minimum during May and early June, then a rise with fluctuations to a maximum in August, followed by a decrease during the autumn to a level which is rather constant through the winter. Thus far, Lake Madison and the Southeast Bay of Lake Herman reach higher maxima of COD levels than the remainder of Lake Herman, but for the most part the level in both lakes has remained between 25 and 75 mg/l COD.

Conductivity levels in both Lake Madison and Lake Herman follow the same pattern as alkalinity—a sharp decrease during the spring run-off, a rapid rise during the later spring to a level which remains fairly constant during the summer, and a slow rise during the autumn and winter. Except for the minimum at the spring run-off, Lake Herman conductivities range from 700-1500 µmhos/cm at $25^{\circ}$ C. whereas Lake Madison conductivities range from 1450-1850 µmhos/cm at $25^{\circ}$ C. The higher Lake Madison values would result from the sewage effluent containing city water. Madison city water is very hard and, in most homes, is put through a water softener which uses salt. This factor would also account for chloride differences between the two lakes. Lake Madison

Figure 9. Variation of Alkalinity in Lakes Madison and Herman During 1970.

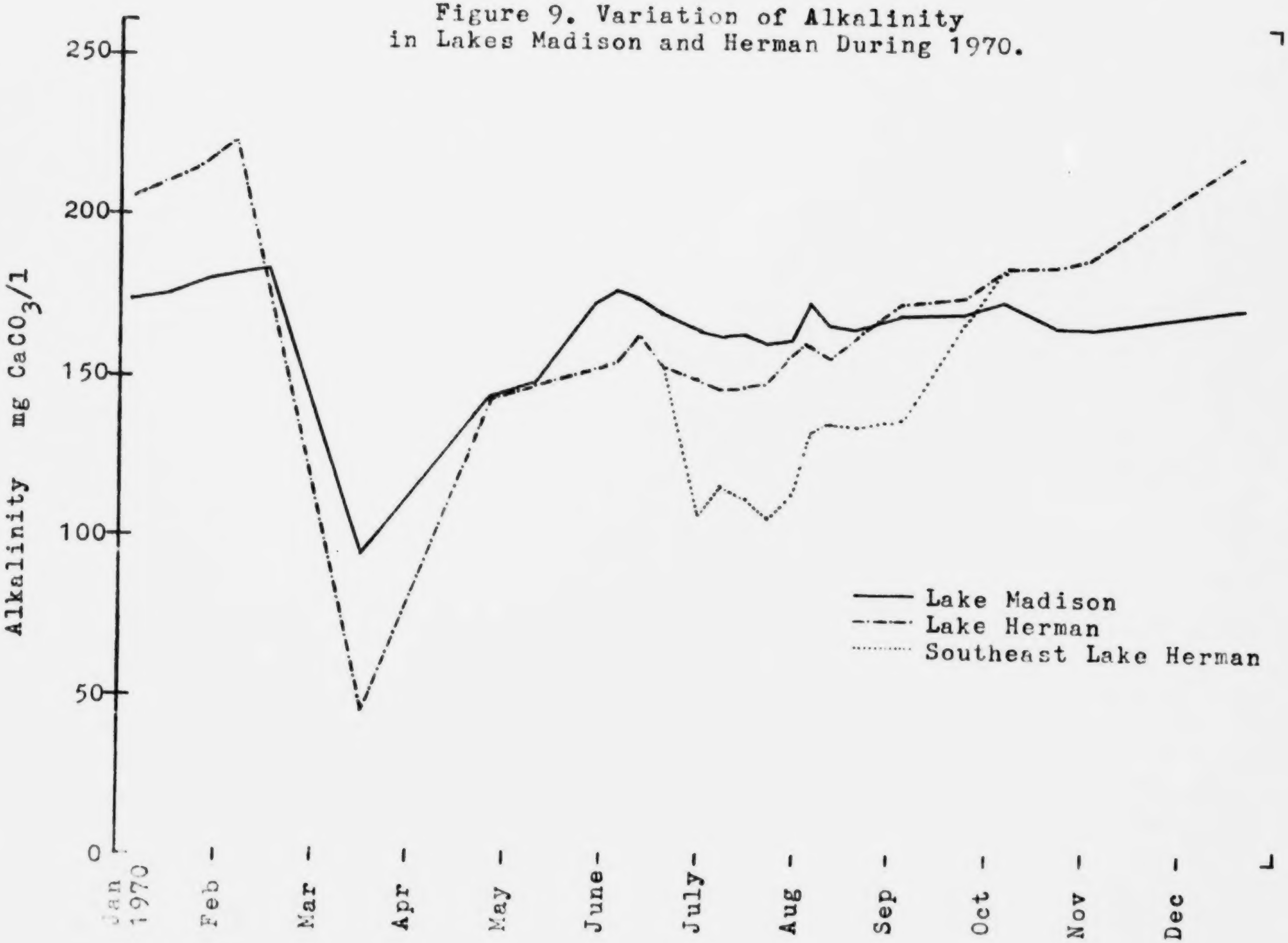
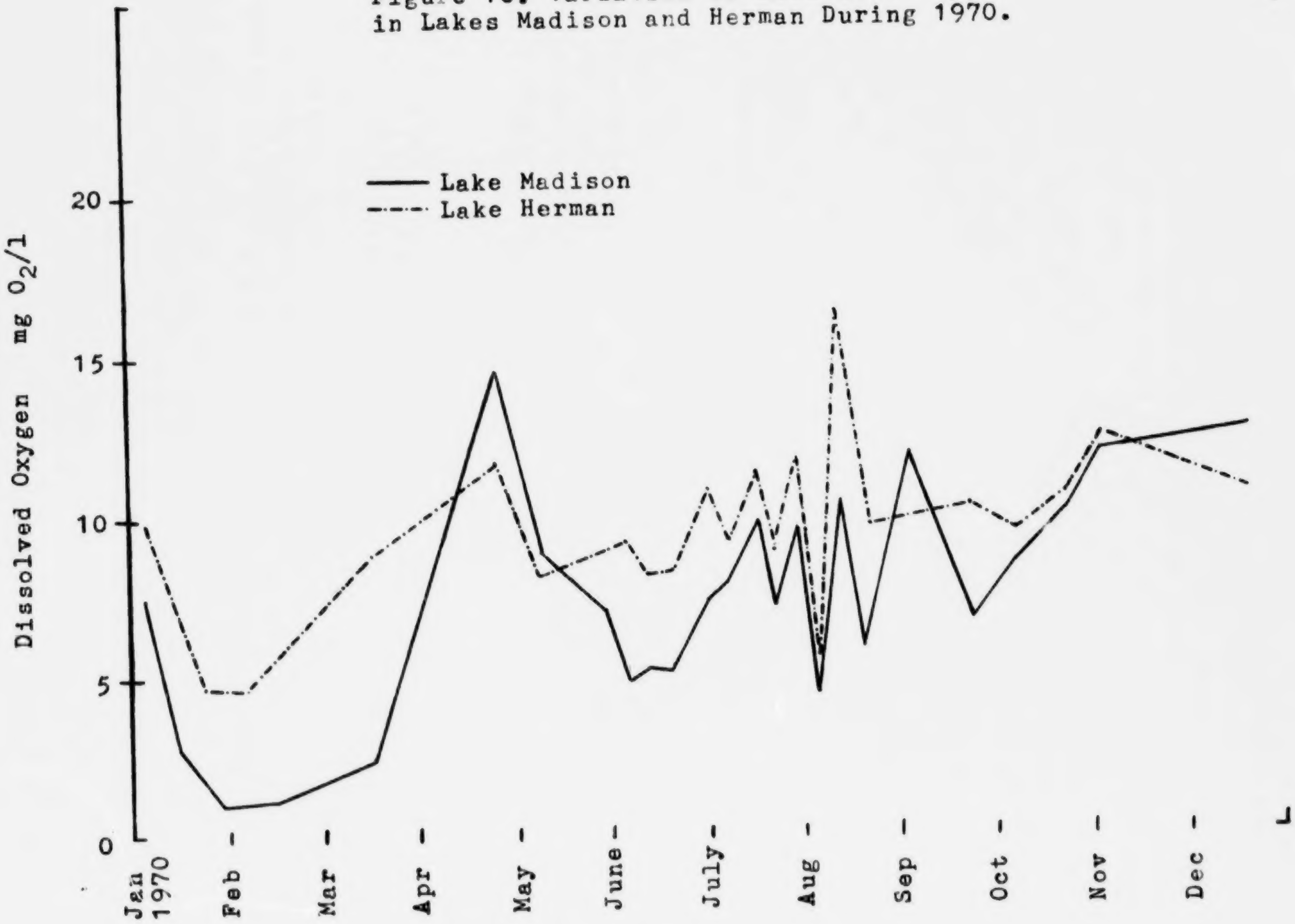


Figure 10. Variation of Dissolved Oxygen in Lakes Madison and Herman During 1970.



has chloride levels around 150 mg/1 Cl whereas Lake Herman chloride levels are around 5 mg/1 Cl. The chloride level in Lake Madison experiences seasonal variation like those of conductivity and alkalinity. However, the chloride level in Lake Herman is very close to constant the year-around, experiencing only a very slight decrease at the time of the spring run-off and a small increase after the ice freeze.

Dissolved silica measurements have been determined only since January of 1970. Figures 11 and 12 show the changes in silica levels in Lake Madison and Lake Herman during 1970 and 1971. The data used for the graph represent averages of the results listed in Appendices A and C. Again, since the Southeast Lake Herman sample has varied somewhat from the remainder of the lake during the past year, it is graphed separately. The seasonal variation in silica follows the same broad pattern in both lakes but this pattern is quite different than that for any of the other chemical parameters. An examination of Figures 11 and 12 indicates that silica levels drop at the time of the spring run-off (particularly in Lake Herman) and continue to drop even more rapidly into early May, then rise sharply and level out until October when there is another drop. These spring and fall decreases correspond with diatom blooms.

Ortho Phosphate measurements have been determined since October, 1969. The normal levels in both lakes range from 0.1-0.5 mg/1 $PO_4$. Figure 13 shows the seasonal changes of ortho phosphate in Lake Madison and Lake Herman during 1970. The data used for the graph represent averages of the results listed in Appendices A and C. Again, since the Southeast Lake Herman sample varied somewhat from the remainder of the lake during the last year of the project, it is graphed separately from June to the end of the year. As may be noted, there is a sharp rise in ortho phosphate levels in both lakes at the time of the spring run-off. This rise is followed by a decrease to a near minima in late April and early May, summer fluctuations, and a fairly constant level during the fall and winter months. The summer fluctuations do not always coincide between the two lakes. The rise in ortho phosphate in Lake Herman in July of 1970 corresponds to the beginning of dredging activity on that lake. Note the Southeast Bay of Lake Herman also shows this rise but it is delayed from that of the remainder of the lake. This delay is reasonable when the restriction of water flow to this area is considered.

Total phosphorus has been determined on both lakes since the beginning of the project. Seasonal variations of total phosphorus in both lakes during 1968, 1969, 1970 and 1971 are shown in Figures 14-17 respectively. The data used for the graphs represent averages of the results listed in Appendices A and C. Since Southeast Lake Herman was not uniform with the remainder of the lake the last year of this project, it is graphed separately during that time. It may be noted that the normal level in both lakes ranges from 0.3 to 1.5 mg/1 $PO_4$. Both lakes follow the same seasonal pattern—an increase during the spring run-off, a decrease in late April and early May to minimal values, summer fluctuations, and a

Figure 11. Variation of Silica in Lakes Madison and Herman During 1970.

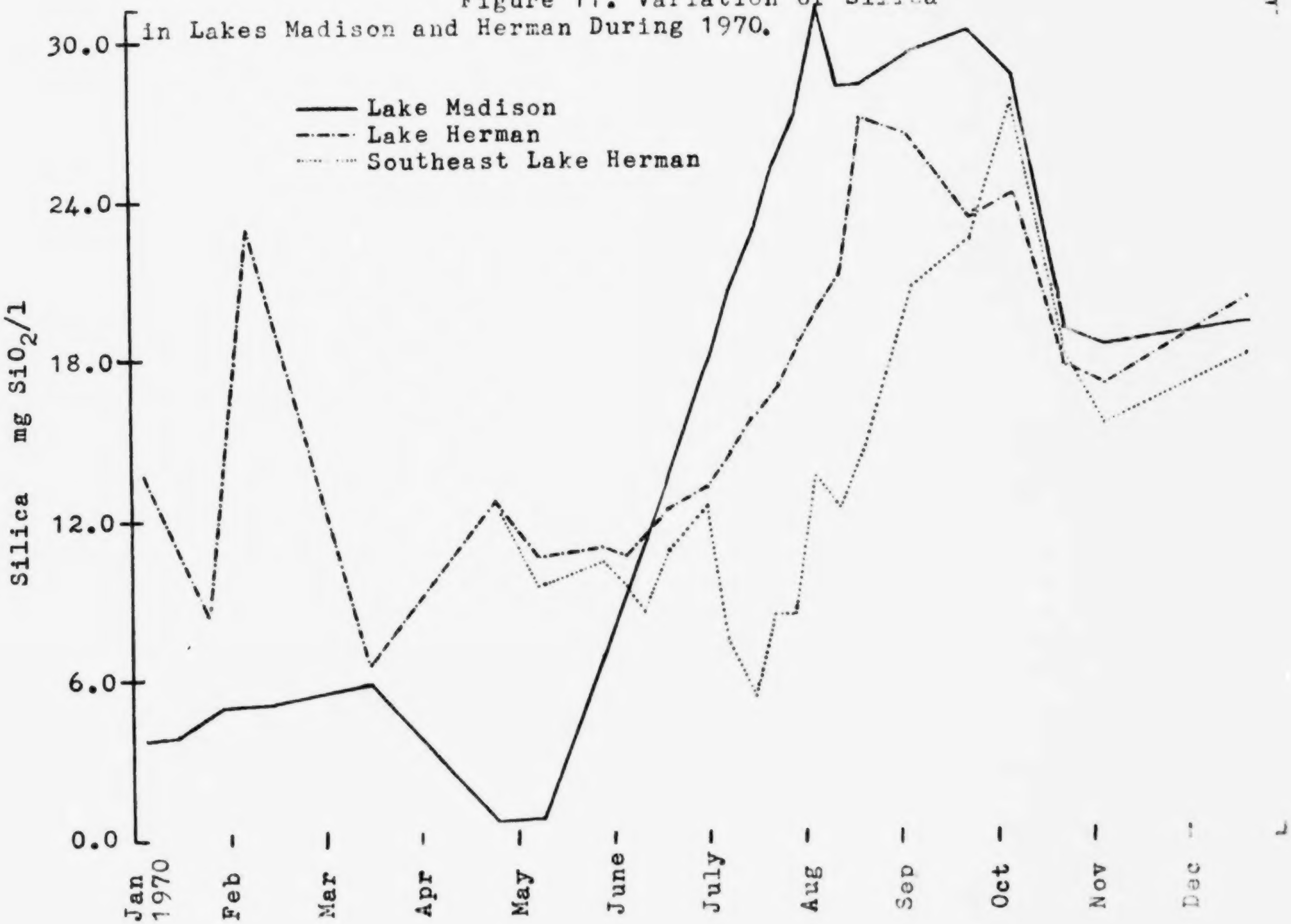


Figure 12. Variation of Silica in Lakes Madison and Herman During 1971.

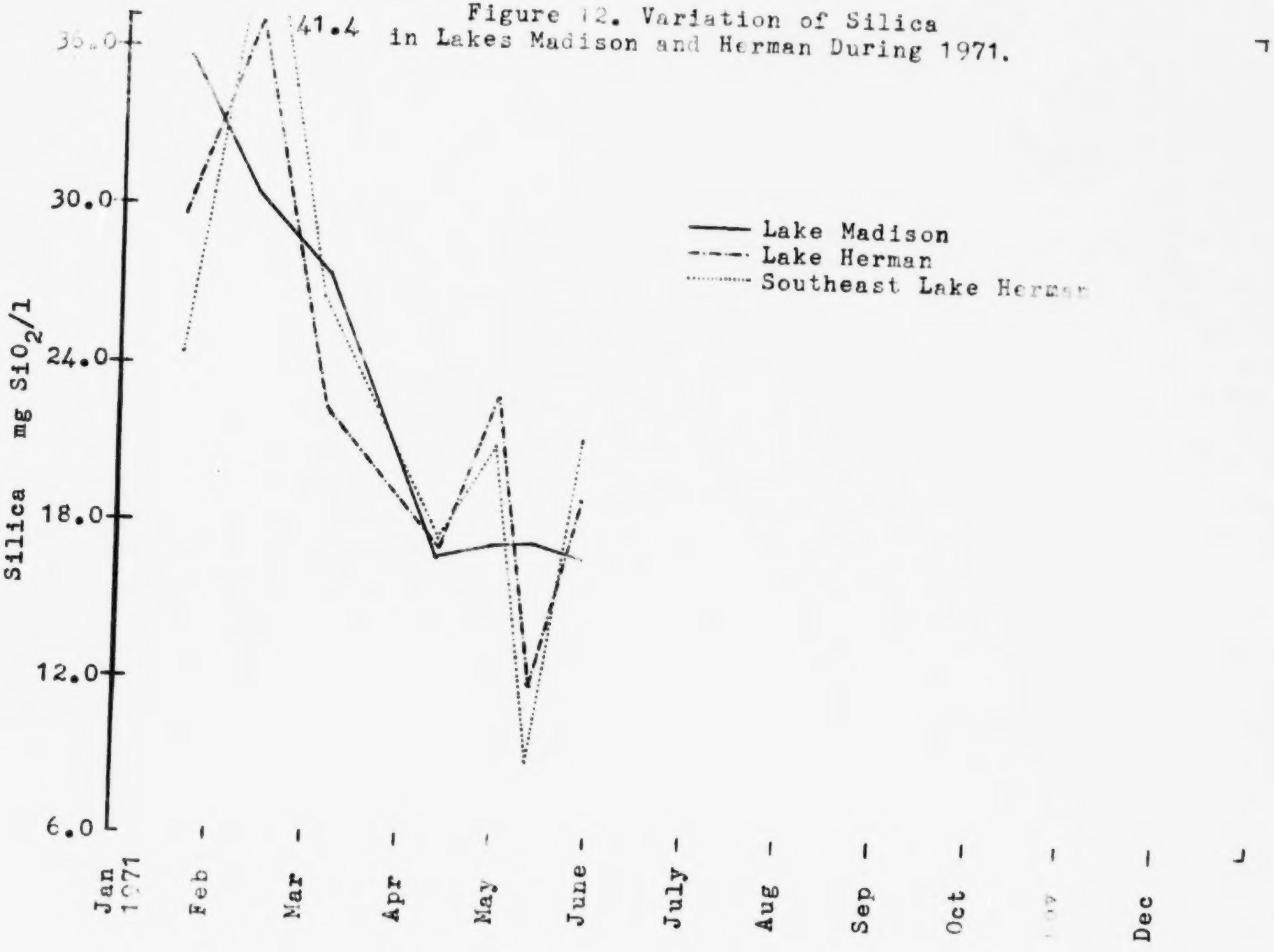
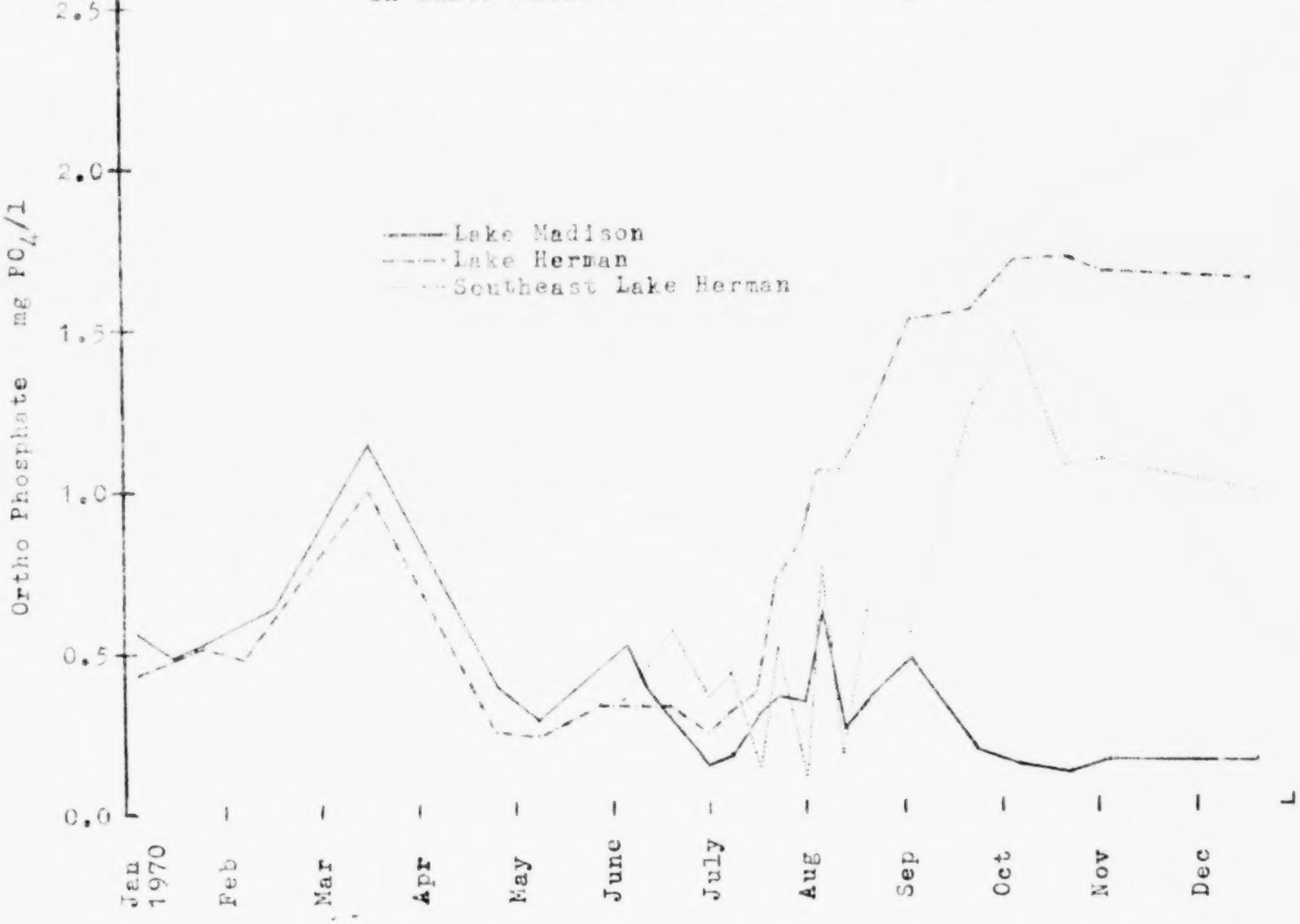


Figure 13. Variation in Ortho Phosphate in Lakes Madison and Herman During 1970.



fairly constant level during the fall and winter months. As with ortho phosphate, the rise of total phosphorus in Lake Herman in July of 1970 corresponds to a dredging project. This project is being studied with the aid of a grant from OWRR—a report will be made on that study during the summer, 1972. The summer fluctuations on the two lakes do not always correspond. They are probably due primarily to algal bloom cycles. It is interesting to note that Lake Madison had higher levels of total phosphorus than Lake Herman until after the heavy spring run-off of 1969. The 100% increase in total phosphorus levels in Lake Herman from the summer and fall of 1968 to the corresponding time of 1969 may be attributed to the heavy run-off with its accompanying silt load in the spring of 1969. From Figure 16, it may be seen that after the light 1970 spring run-off the level of total phosphorus in Lake Herman began falling below that of Lake Madison only to increase rapidly with the commencement of dredging activities. Examining Figures 14-17 with regard to total phosphorus levels in Lake Madison indicates that this level has undergone an overall decrease during the three years of this project.

Nitrate levels were determined for the first fifteen months of this project as combined nitrate and nitrite and since that time as just nitrate. The seasonal nitrate levels in both lakes during 1968, 1969, 1970 and 1971 are depicted in Figures 18-21 respectively. The data used for these graphs represent averages of the results listed in Appendices A and C; again, since the Southeast Lake Herman sample varied somewhat from the remainder of the lake the last year of the project, it is graphed separately during that time. It may be noted from an examination of Figures 18-21 that seasonal changes in nitrate levels in both lakes follow the same general pattern as the phosphorus levels. A sharp increase during spring run-off is followed by a decrease to near minimal values and summer fluctuations which, in the case of nitrate, continue into the fall. The summer and fall fluctuations are probably related to the algal bloom cycles. It is of interest to note the maximum nitrate levels reached during the spring run-offs. It may be concluded from the maximum of each year that Lake Herman was affected by run-off to a higher degree than Lake Madison. It is also apparent that larger run-offs (1969) caused higher maxima and longer recovery times for the lake. For instance with the largest run-off in 1969, the Lake Herman maxima reached 2.75 mg/l $NO_3^-N$ and it was the middle of July before the nitrate level had fallen to near zero whereas in the lightest run-off year, 1971, the Lake Herman nitrate level reached a maxima of less than 0.85 mg/l $NO_3^-N$ and had returned to a near zero level by the middle of April.

The separate nitrite concentrations determined since the fall of 1969 and ammonia levels in the two lakes follow the same general pattern as the nitrate levels. The high ammonia levels during the fall of 1968 and 1969 are most likely invalid, arising from the analytical method used at that time—direct Nesslerization of fall water samples from both lakes tended to produce turbid suspensions. The simultaneous rise of ammonia and nitrite during late May and early June of 1970 in Lake Madison is probably related to a biological change. Both ammonia and

Figure 14. Variation of Total Phosphorus in Lakes Madison and Herman During 1968.

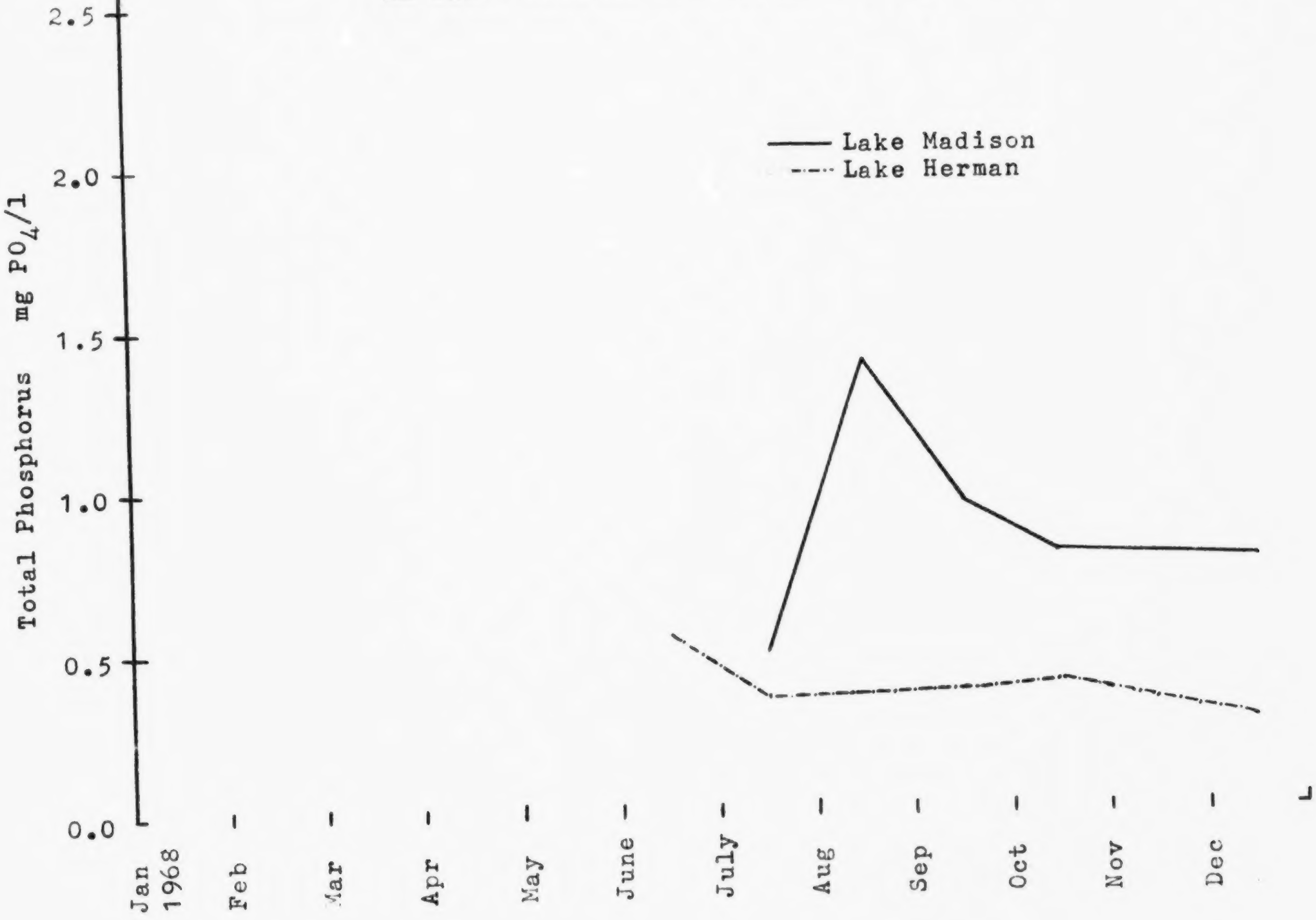


Figure 15. Variation of Total Phosphorus in Lakes Madison and Herman During 1969.

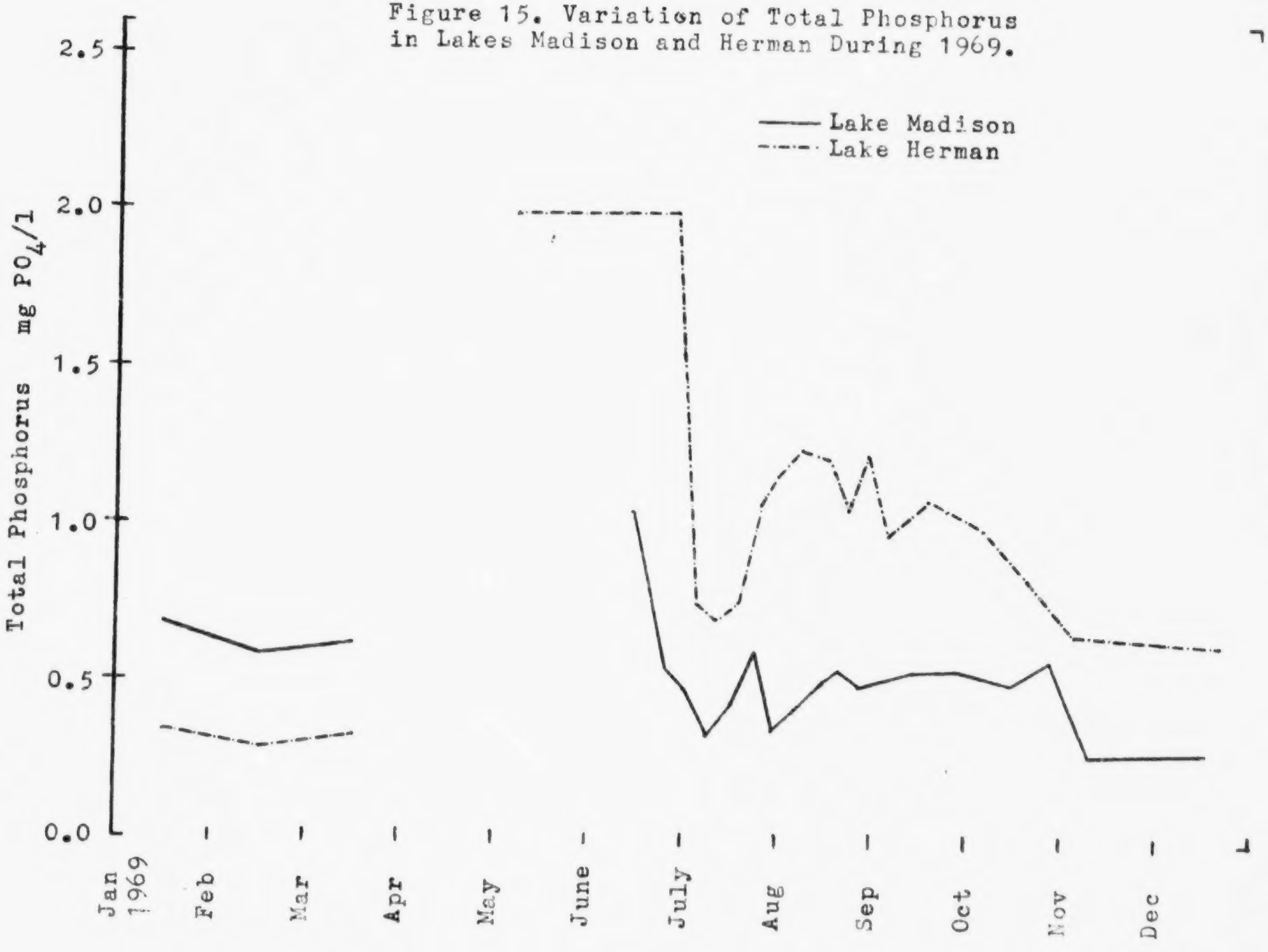
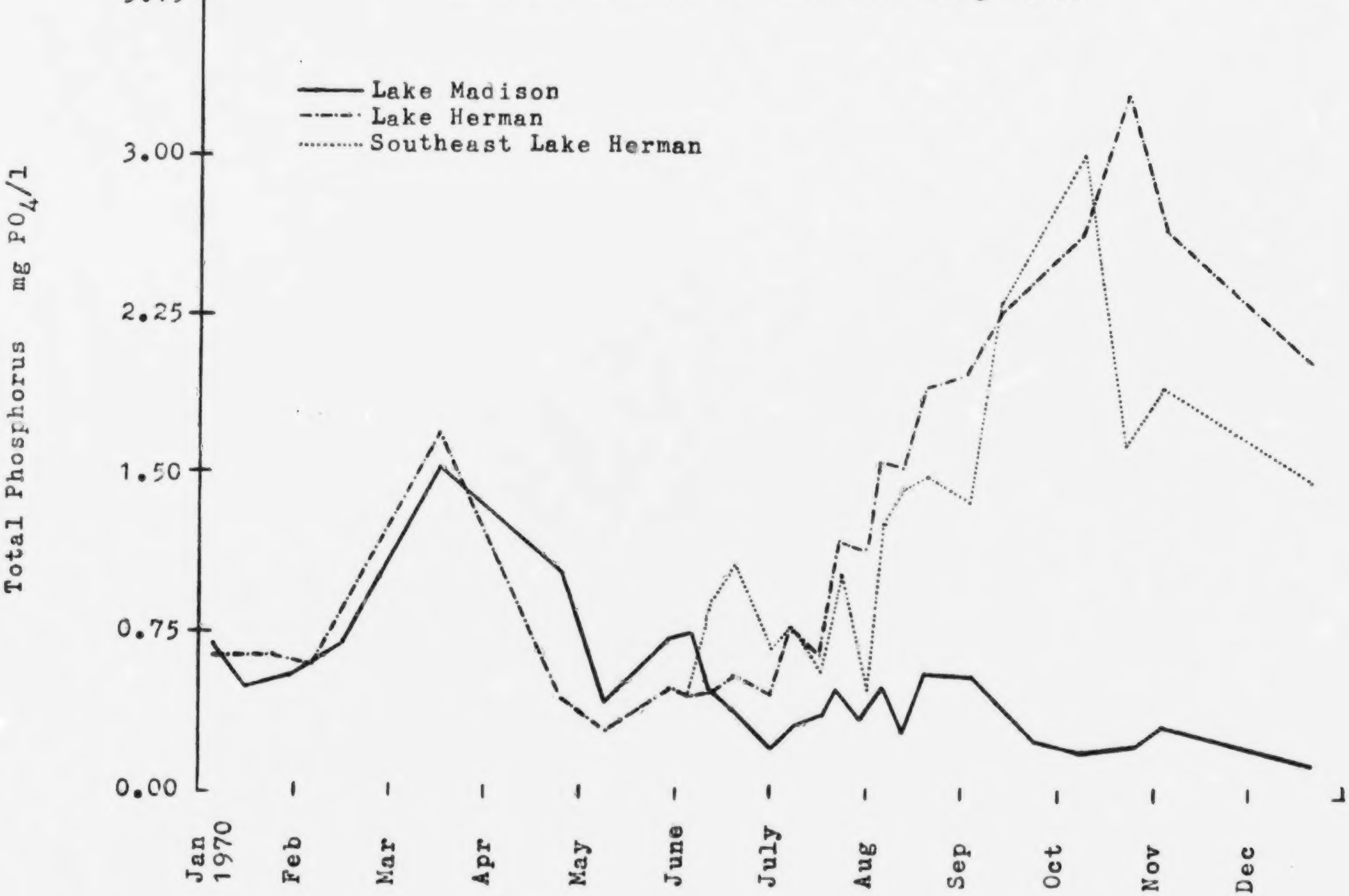


Figure 16. Variation of Total Phosphorus in Lakes Madison and Herman During 1970.



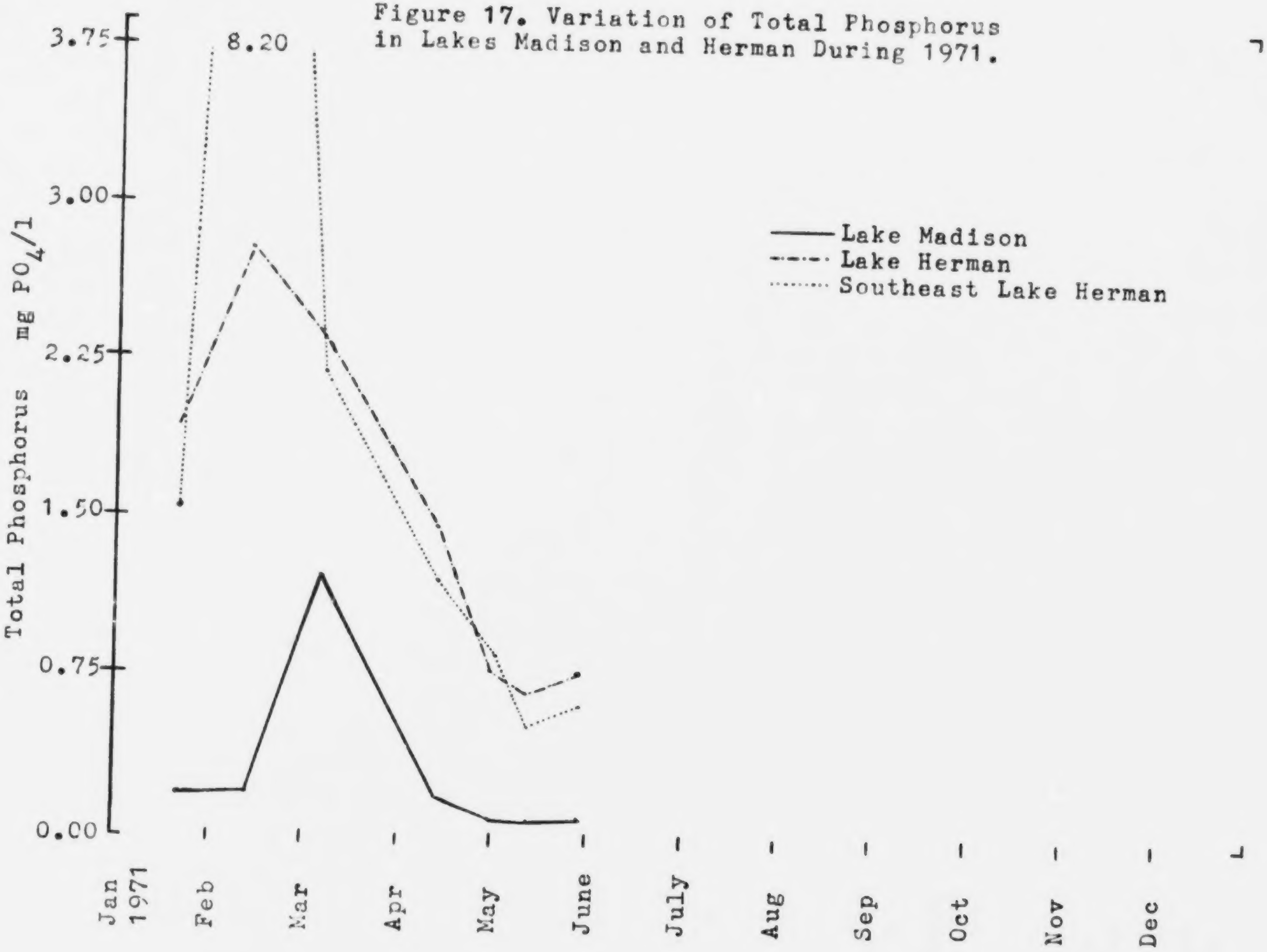


Figure 17. Variation of Total Phosphorus in Lakes Madison and Herman During 1971.

Figure 18. Variation of Nitrate in Lakes Madison and Herman During 1968.

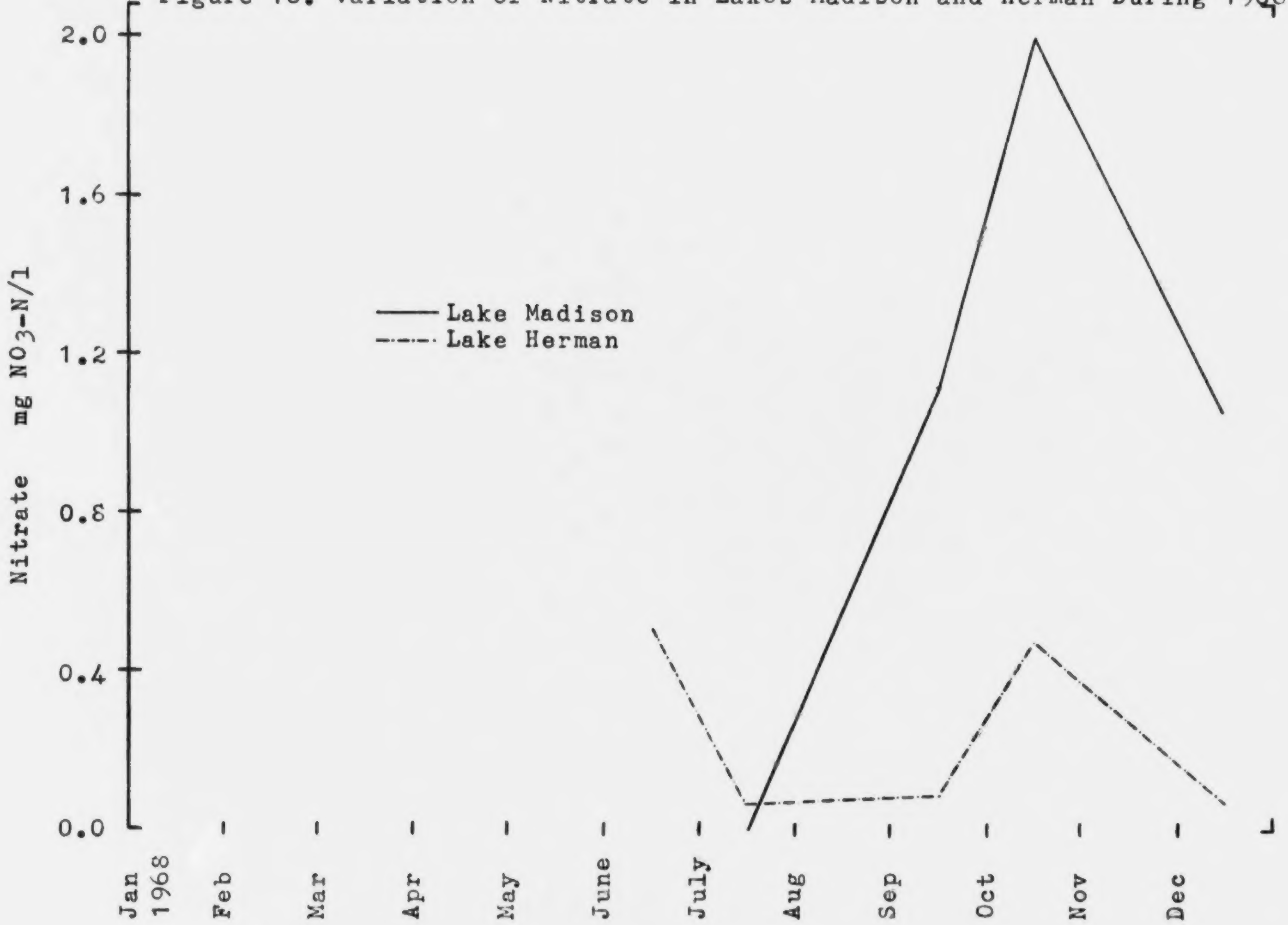


Figure 19. Variation of Nitrate in Lakes Madison and Herman During 1969.

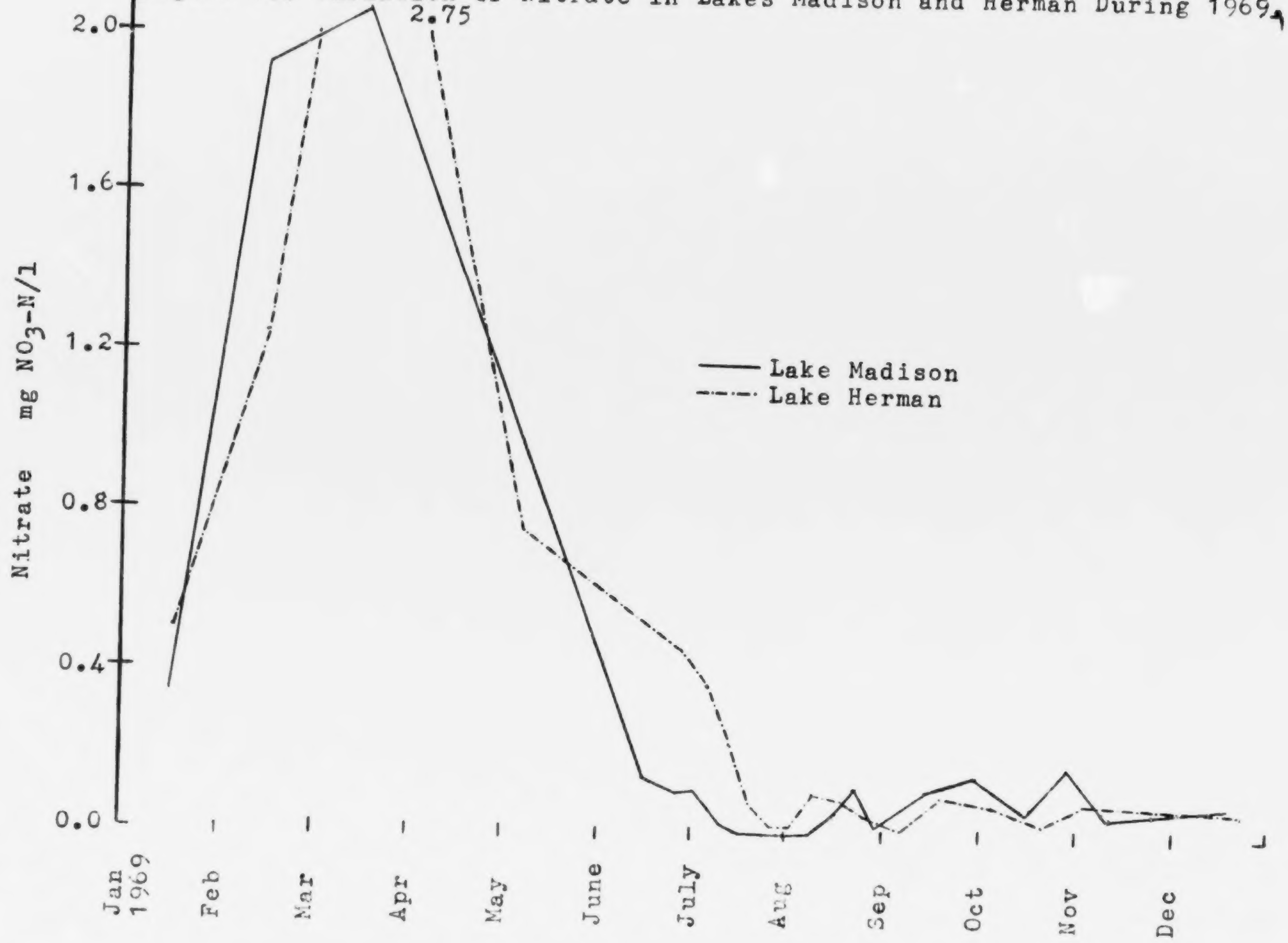


Figure 20. Variation of Nitrate in Lakes Madison and Herman During 1970.

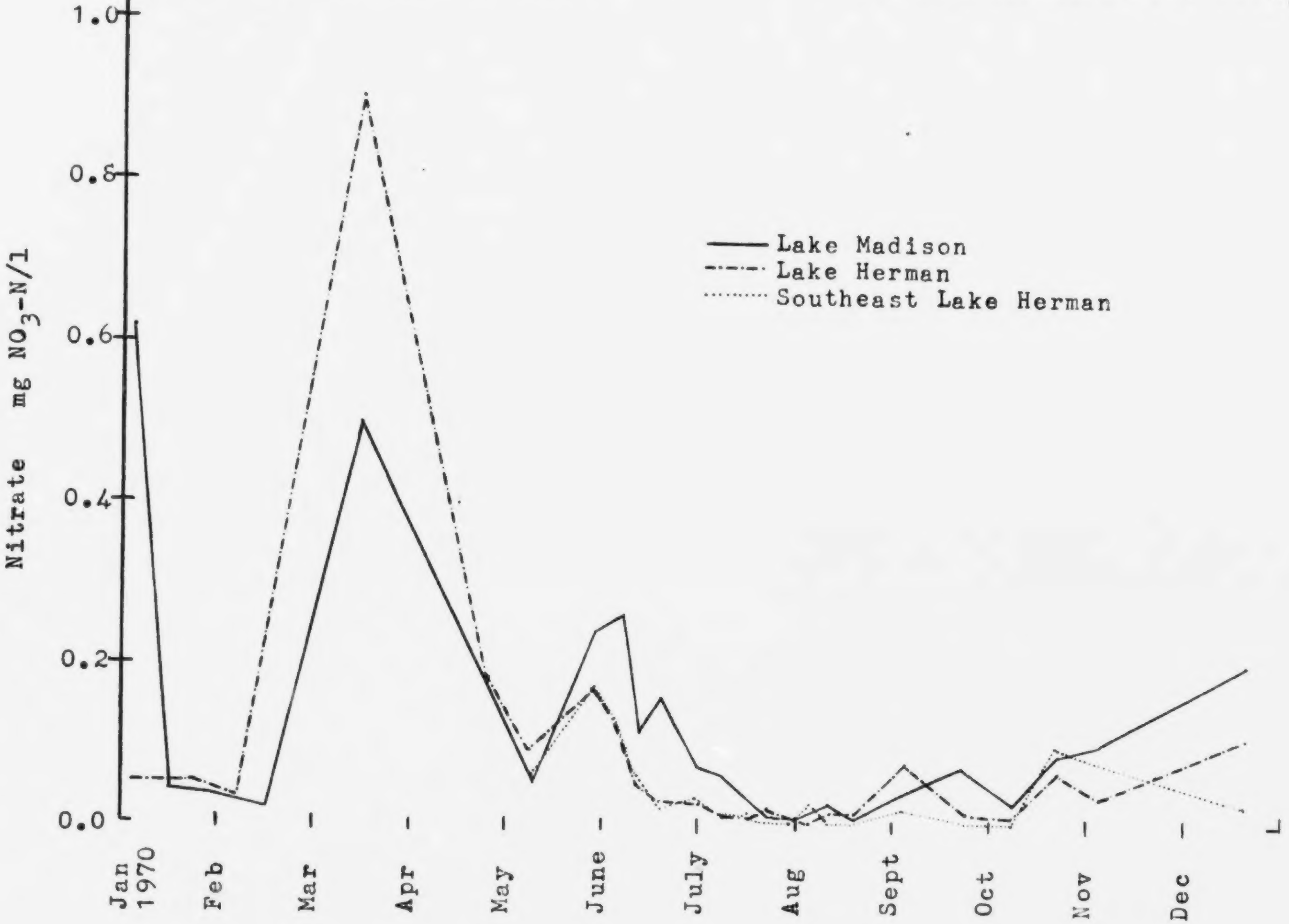
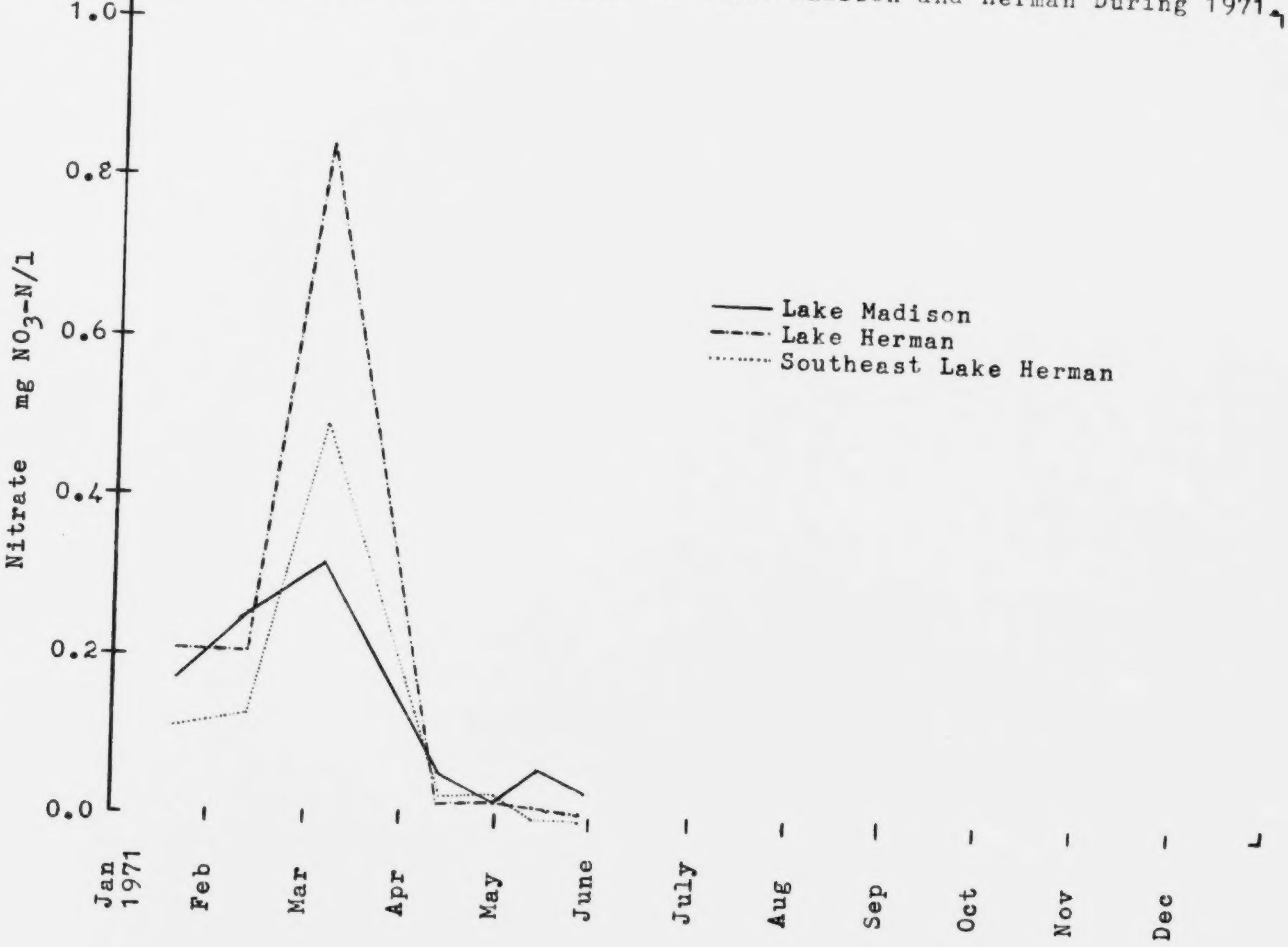


Figure 21. Variation of Nitrate in Lakes Madison and Herman During 1971.



nitrite levels tend to be slightly higher in Lake Madison than in Lake Herman.

The temperature variation in both lakes through this project is what would be expected from the season of the year and the air temperature. There are fluctuations during the summer months which coincide very closely between the two lakes. One difference between the lakes is that Lake Herman tends to warm up faster in the spring, cool off faster in the fall, and experiences summer fluctuations to a greater degree than Lake Madison. This difference is not surprising considering that Lake Herman has a much smaller total water volume.

Figure 22 shows a plot of the seasonal variation in temperature, dissolved oxygen and pH in Lake Herman during 1970. The fact that the summer fluctuations in these three parameters all coincide is indicative of at least an indirect relationship between them.

Secchi disk readings and turbidities in the two lakes generally coincide as would be expected; when secchi disk readings decrease, turbidity, increases and vice versa. The time of greatest water clarity, greatest secchi disk readings and lowest turbidity, tends to occur during the winter and also in early June. The times of lowest water clarity occur in July and August, at the height of the algal blooms, and in the spring, during the spring run-offs. Except for the two periods of maximum clarity, secchi disk readings tend to be in the range of 20-120 cm. From July, 1969, to May, 1971, secchi disk readings on Lake Madison have shown an overall increase whereas those on Lake Herman have shown an overall decrease.

Concentration levels of hardness and calcium follow the same seasonal pattern in both Lake Madison and Lake Herman. The seasonal changes of hardness in the two lakes during 1968, 1969, 1970 and 1971 are shown in Figures 23-26 respectively. The data used for the graphs represent averages of the results listed in Appendices A and C. Since the Southeast Lake Herman sample varied somewhat from the remainder of the lake the last year of the project, it is graphed separately during 1970 and 1971. Through most of the year hardness levels in Lake Madison range from 540 to 850 mg/l $CaCO_3$ while those in Lake Herman range from 260 to 720 mg/l $CaCO_3$. Lake Madison also has a correspondingly higher level of calcium. Both hardness and calcium follow a seasonal pattern like that of alkalinity—a sharp decrease at the time of the spring run-off, followed by an increase during April and May to a level which remains nearly constant through the summer and fall, and a rise after the ice freeze. The level of hardness and the time to rise to a constant level after the spring run-off is related to the amount of the spring run-off. Note the lower hardness levels and the longer recovery time after the heavy spring run-off of 1969 (see Figure 24). There seems to be consistently a slight decrease in the hardness level in both lakes during the latter part of August.

The concentration of magnesium in Lake Madison and Lake Herman has been measured since January of 1970. Figures 27 and 28 depict the seasonal

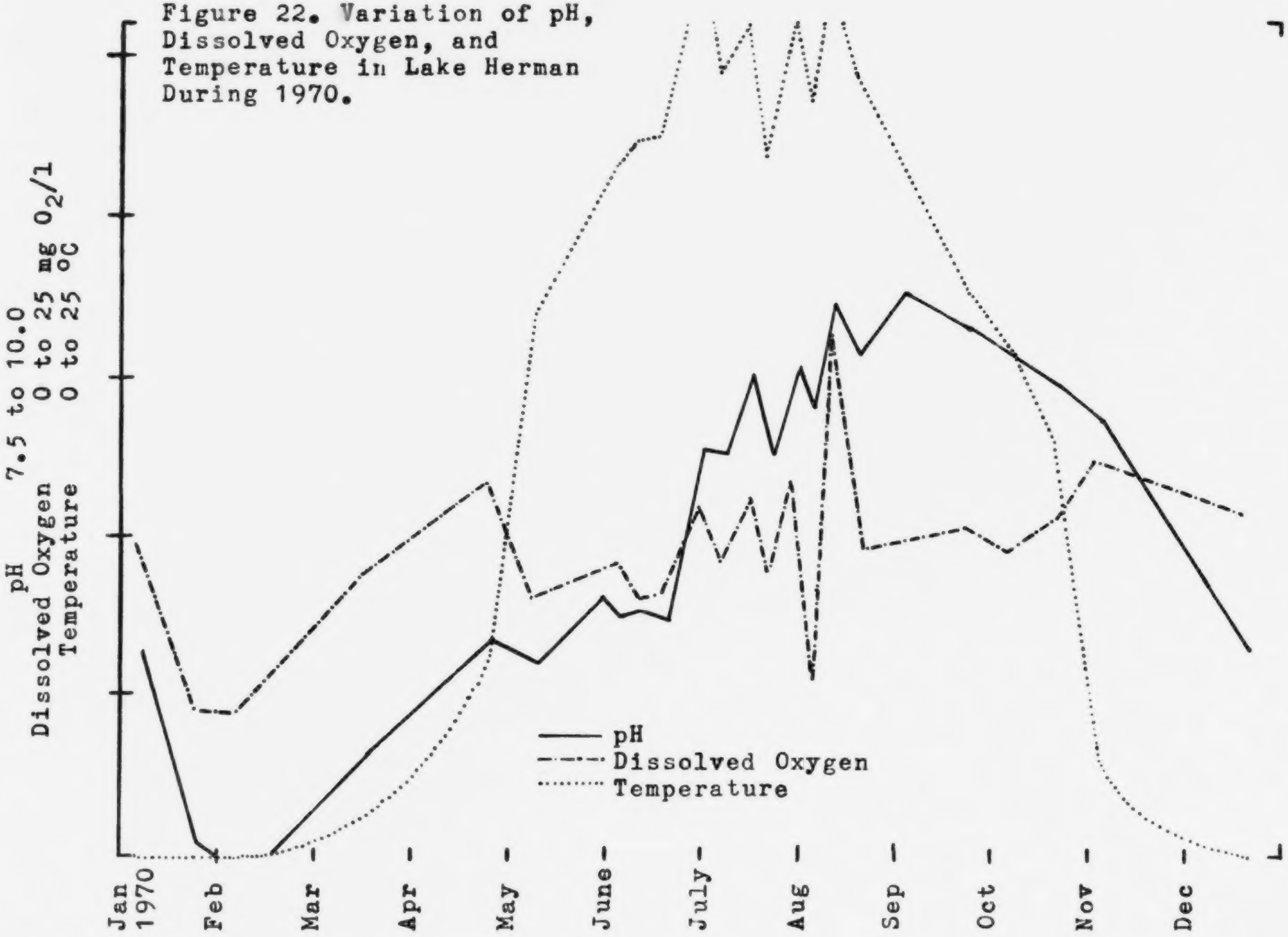


Figure 22. Variation of pH, Dissolved Oxygen, and Temperature in Lake Herman During 1970.

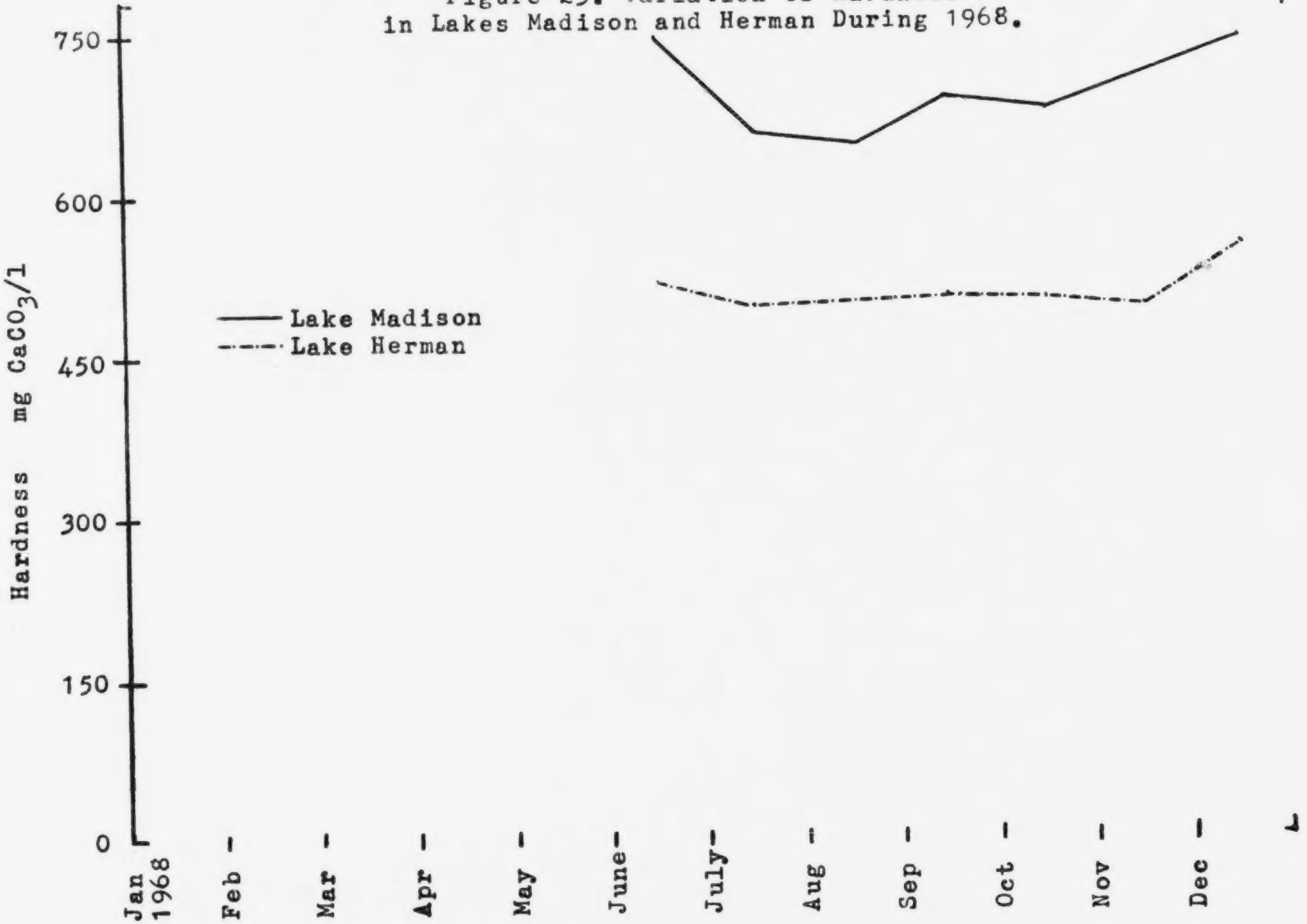
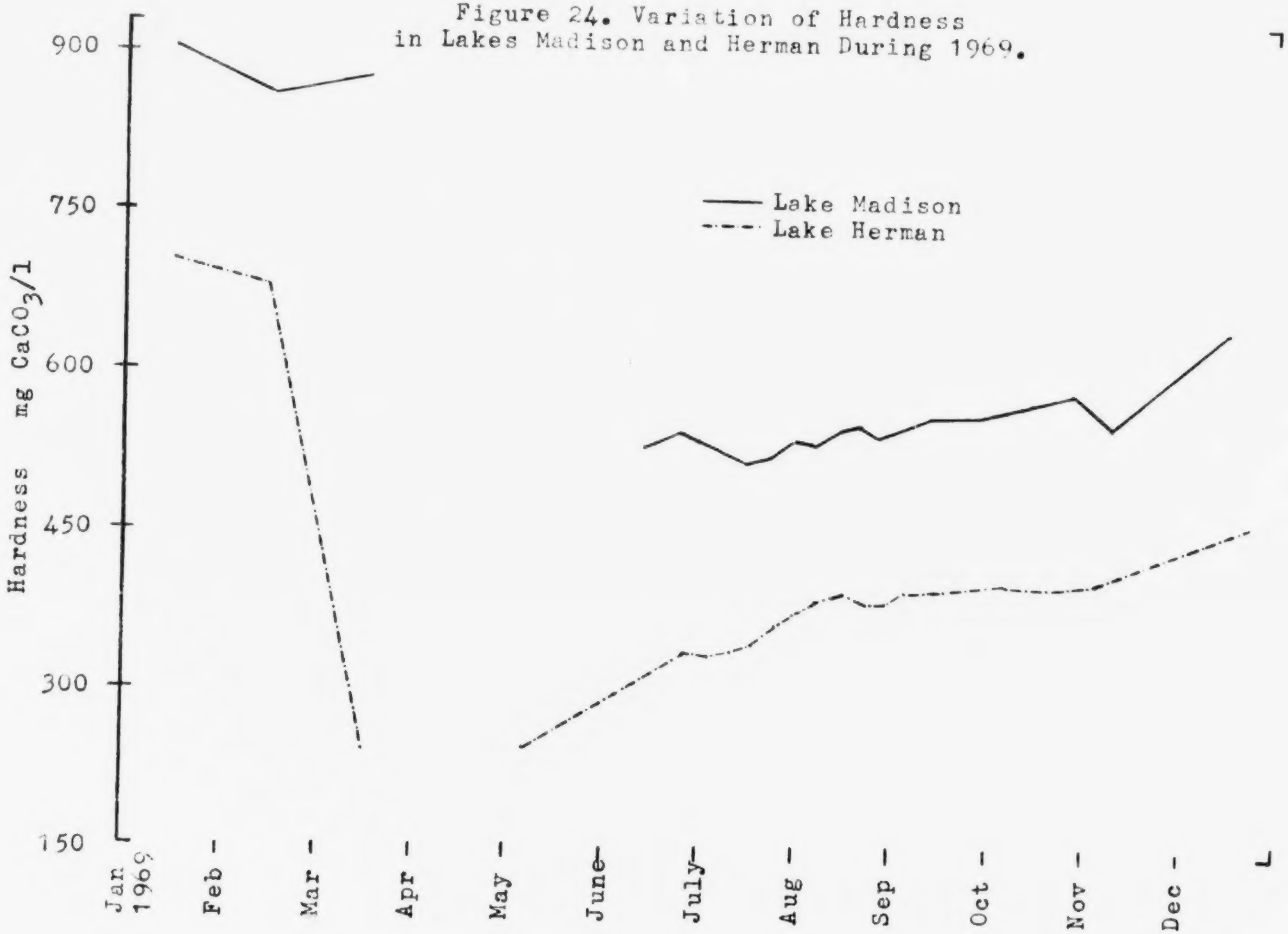


Figure 23. Variation of Hardness in Lakes Madison and Herman During 1968.

Figure 24. Variation of Hardness in Lakes Madison and Herman During 1969.



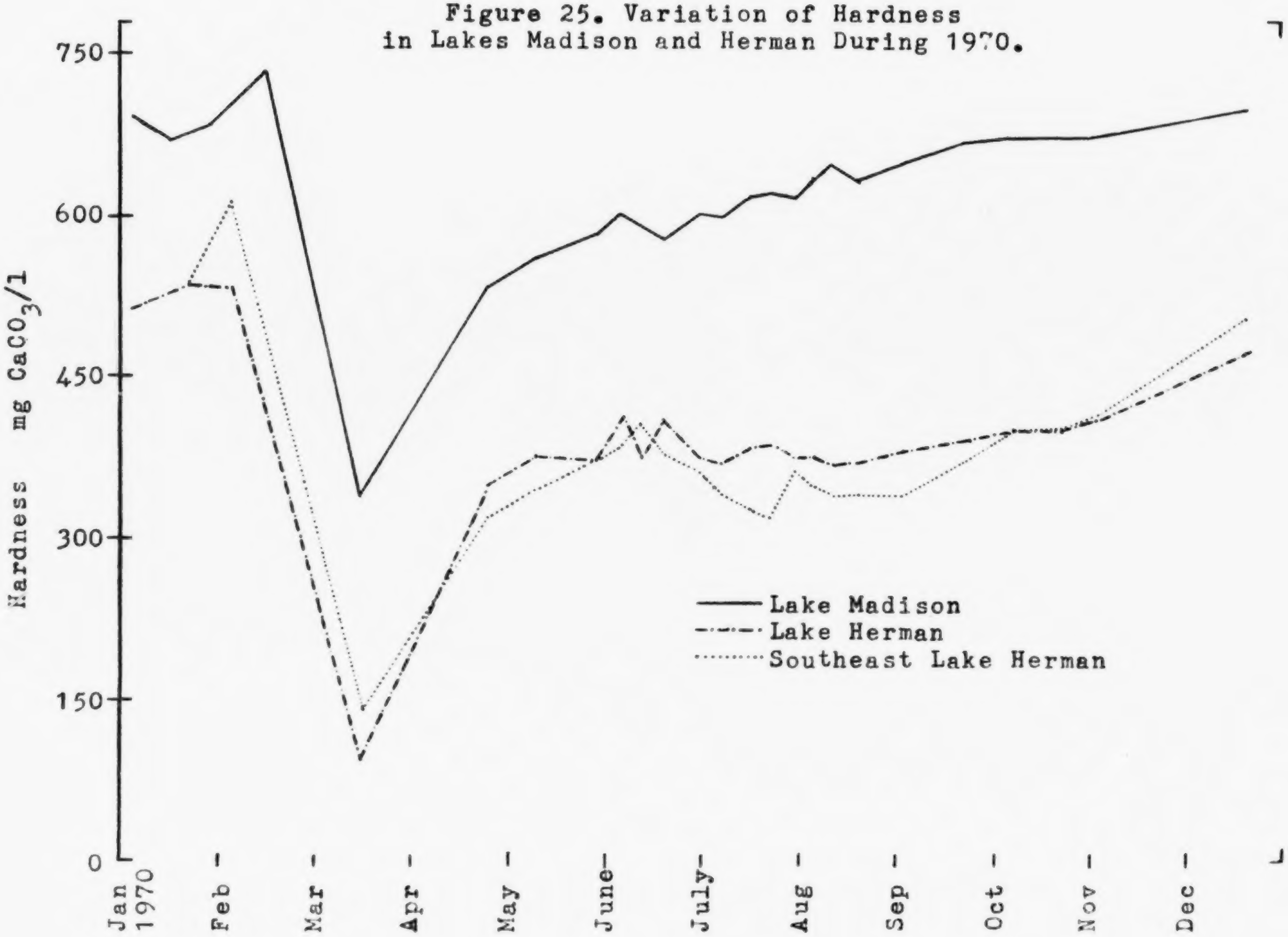


Figure 25. Variation of Hardness in Lakes Madison and Herman During 1970.

Figure 26. Variation of Hardness in Lakes Madison and Herman During 1971.

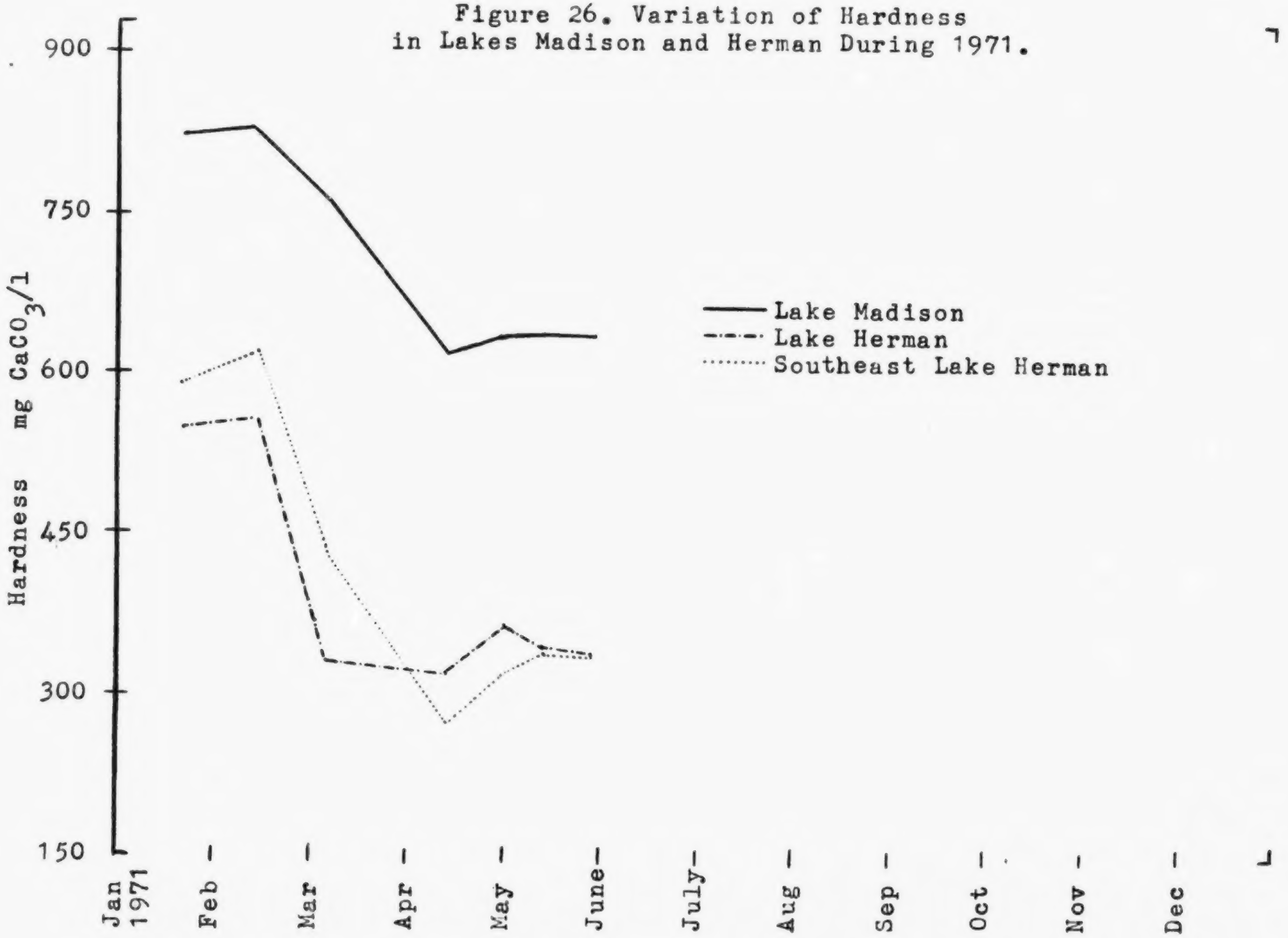


Figure 27. Variation of Magnesium in Lakes Madison and Herman During 1970.

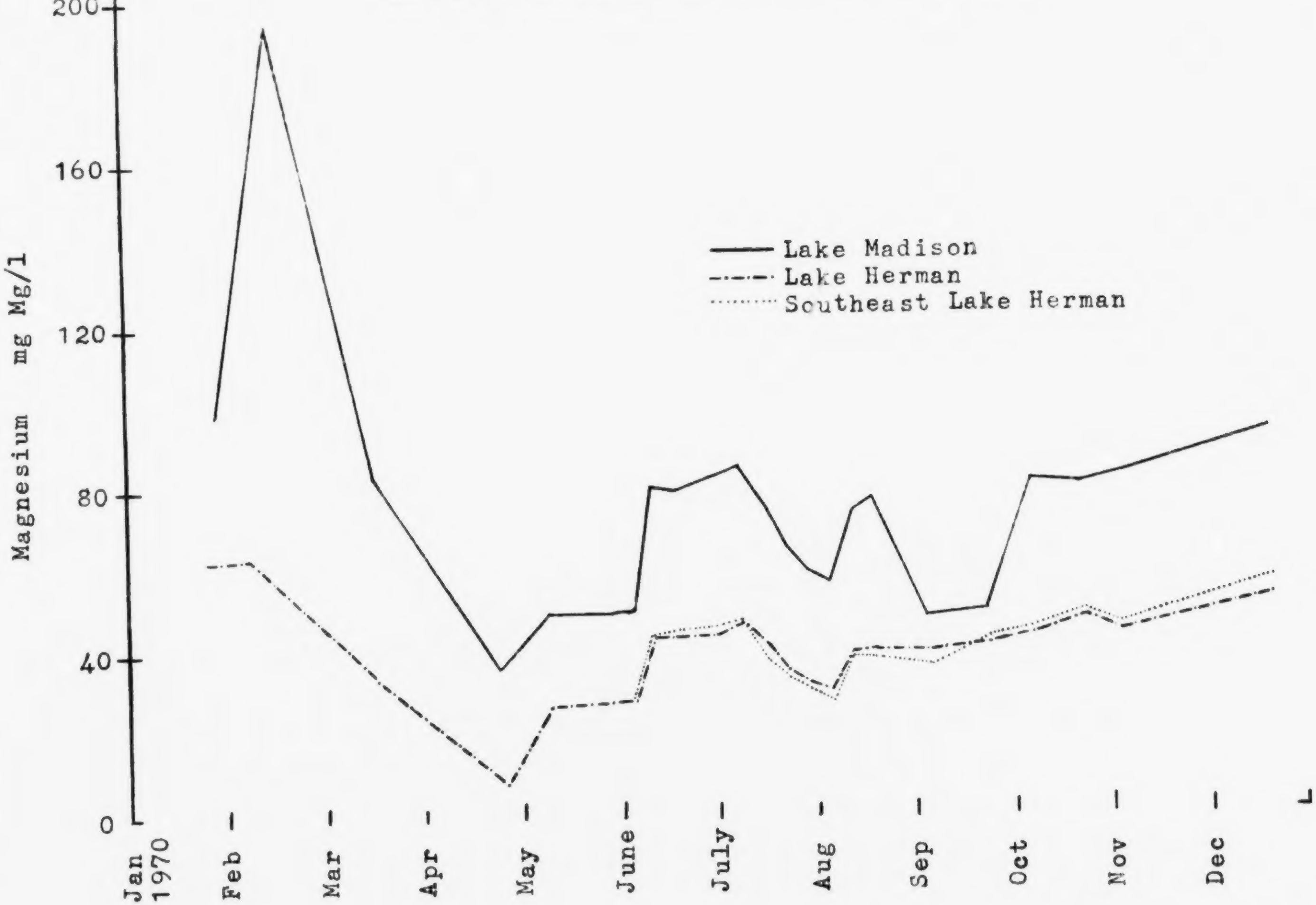
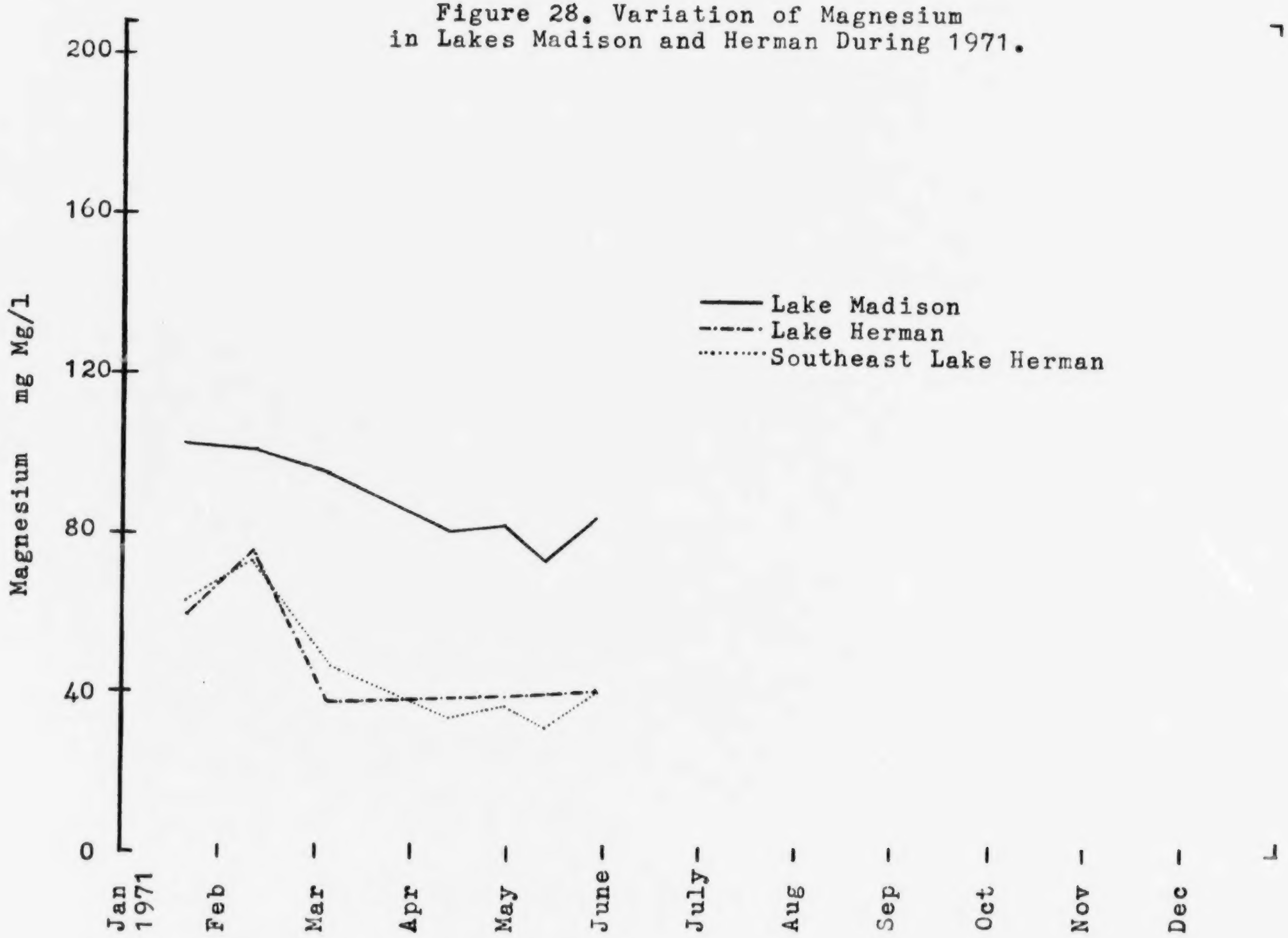


Figure 28. Variation of Magnesium in Lakes Madison and Herman During 1971.



changes in magnesium levels in the two lakes during 1970 and 1971. The data graphed represent averages of the results listed in Appendices A and C. Southeast Lake Herman is graphed separately during the past year. The magnesium levels in Lake Madison generally range from 50 to 110 mg/l Mg while those in Lake Herman are somewhat lower, 25-75 mg/l Mg. The seasonal changes in both lakes follow the same pattern. There is a sharp decrease at the time of the spring run-off followed by a continued decrease into late April or early May and a rise in early June. There are sharp fluctuations during the summer and fall but the level in November is the same as that in June. With the ice freeze, there is a steady rise in magnesium levels until the next run-off. The summer and fall fluctuations generally coincide in the two lakes but occur to a greater degree in Lake Madison. There is an inverse correlation between magnesium and ortho phosphate levels in both lakes. Figure 29 shows this relationship between magnesium and ortho phosphate in Lake Madison during 1970. Considering the insolubility of magnesium phosphate salts, this correlation is not surprising.

Copper levels in both lakes normally range from 0-0.01 mg/l Cu. Between these levels, the concentration in both lakes seems to fluctuate widely for no apparent reason. It is interesting that Lake Madison contains no more copper than Lake Herman in spite of the fact that thousands of pounds of copper sulfate have been used during the past three years as an algicide in Lake Madison. It seems likely that the high pH causes precipitation of this copper and removal to the sediments.

Concentrations of soluble iron in Lake Madison and Lake Herman have been determined since January of 1970. Figures 30 and 31 show iron concentrations in the two lakes through 1970 and 1971 respectively. The data used for the graphs represent averages of the results listed in Appendices A and C. Since the Southeast Lake Herman sample varied somewhat from the remainder of the lake the last year of the project, it is graphed separately during that time. The iron level in both lakes generally ranges from 0.01-0.06 mg/l Fe. As may be noted in Figures 30 and 31, Lake Herman experiences a significant increase in iron at the time of the spring run-off whereas Lake Madison experiences little or no increase at this time. This difference may reasonably be attributed to the silt load of the spring run-off waters entering Lake Herman. The iron levels in both lakes fluctuates through the spring, summer and fall. The summer and fall changes seem to coincide between the two lakes.

The seasonal changes in manganese levels in Lake Madison and Lake Herman during 1970 and 1971 are depicted in Figures 32 and 33. The data used for graphing represents averages of the results listed in Appendices A and C. Since Southeast Lake Herman was not uniform with the remainder of the lake the last year of this project, it is graphed separately during that time interval. Soluble manganese levels, like those of silica, do not really fit into either of the two general patterns followed by most other chemical parameters. Lake Madison and Lake Herman have experienced manganese values as low as 0.01 mg/l Mn and higher than 1.0 mg/l Mn. The maximum level seems to occur just prior to

Figure 29. Variation of Magnesium and Ortho Phosphate in Lake Madison During 1970.

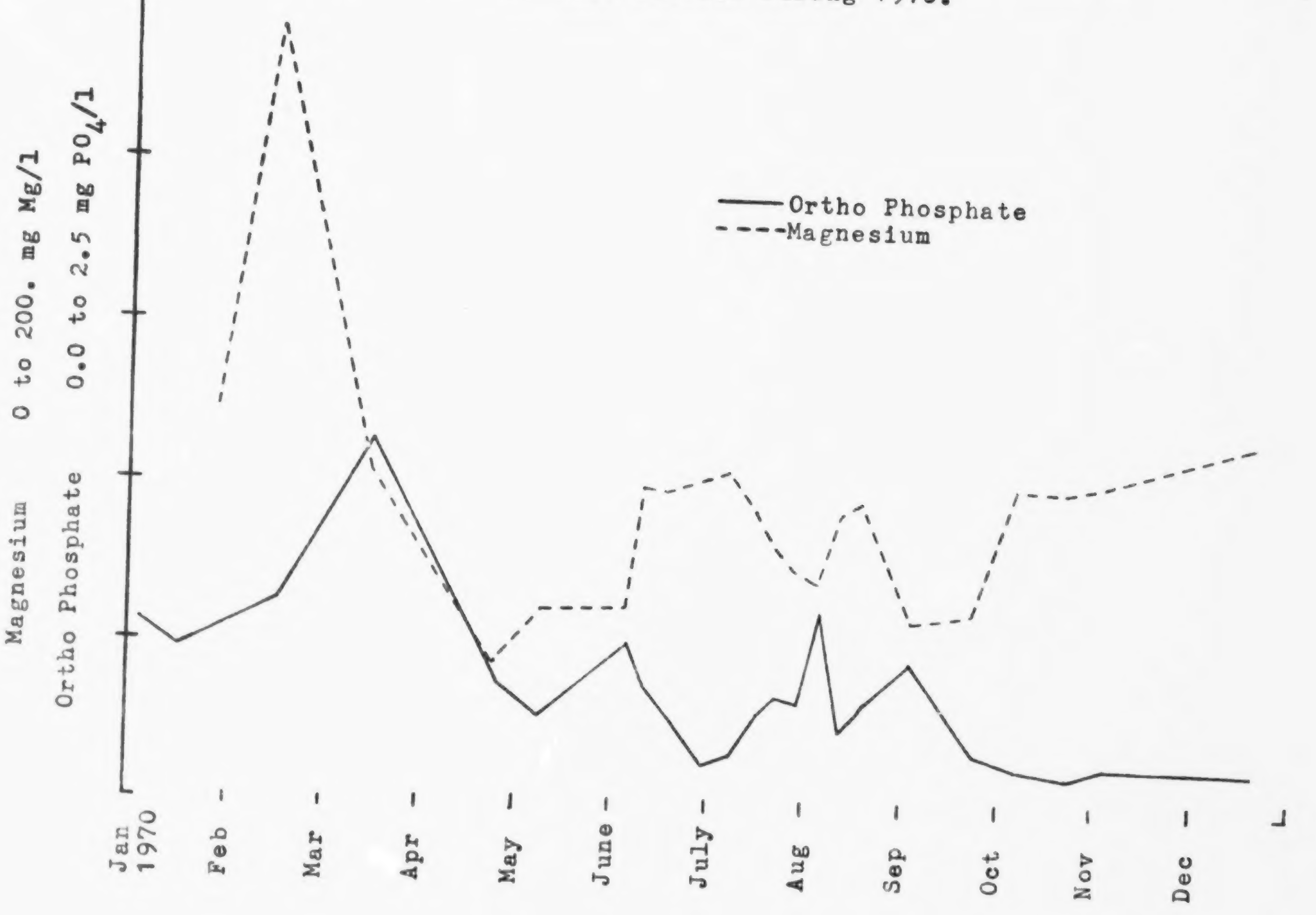


Figure 30. Variation of Iron in Lakes Madison and Herman During 1970.

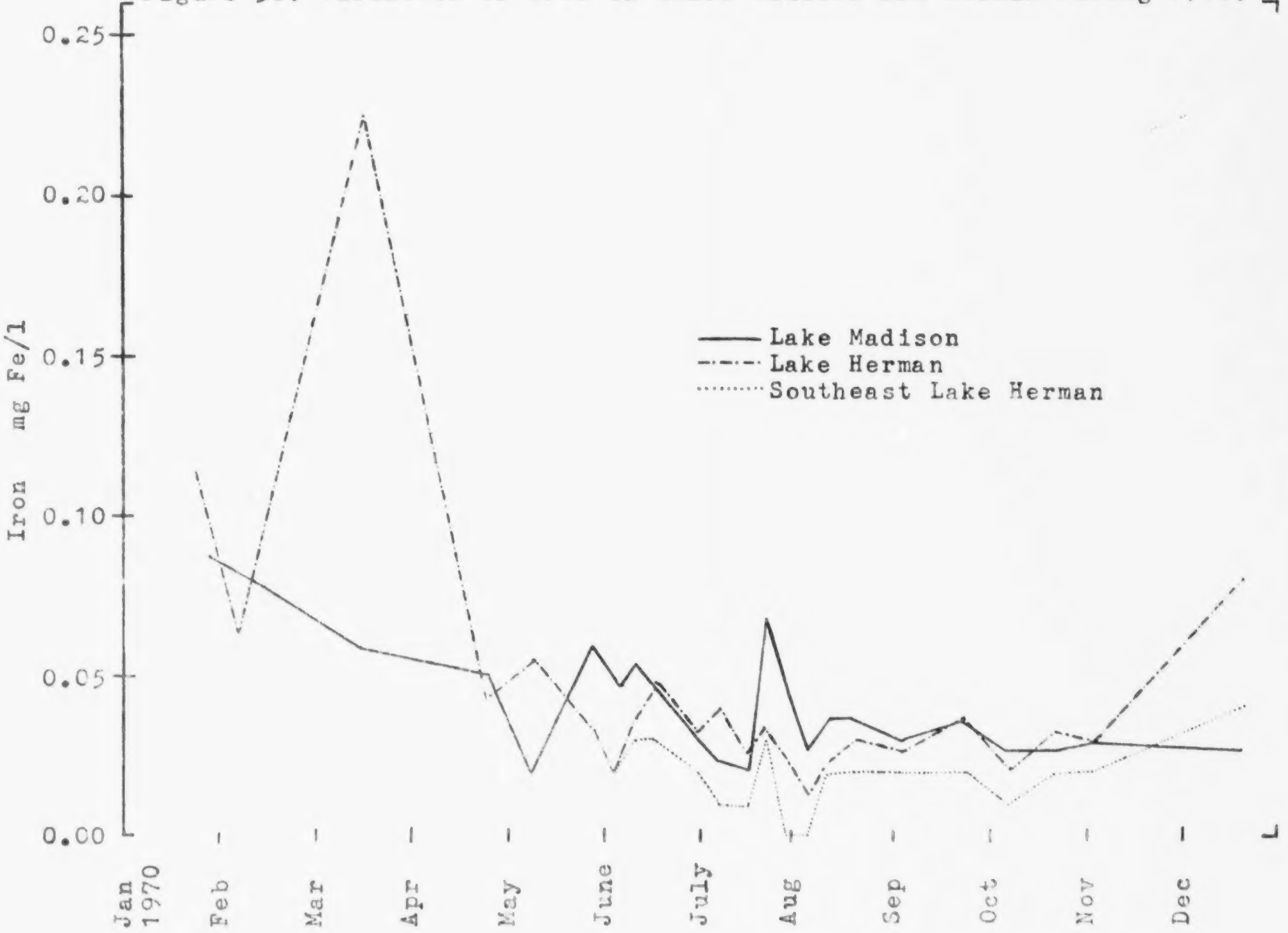


Figure 31. Variation of Iron in Lakes Madison and Herman During 1971.

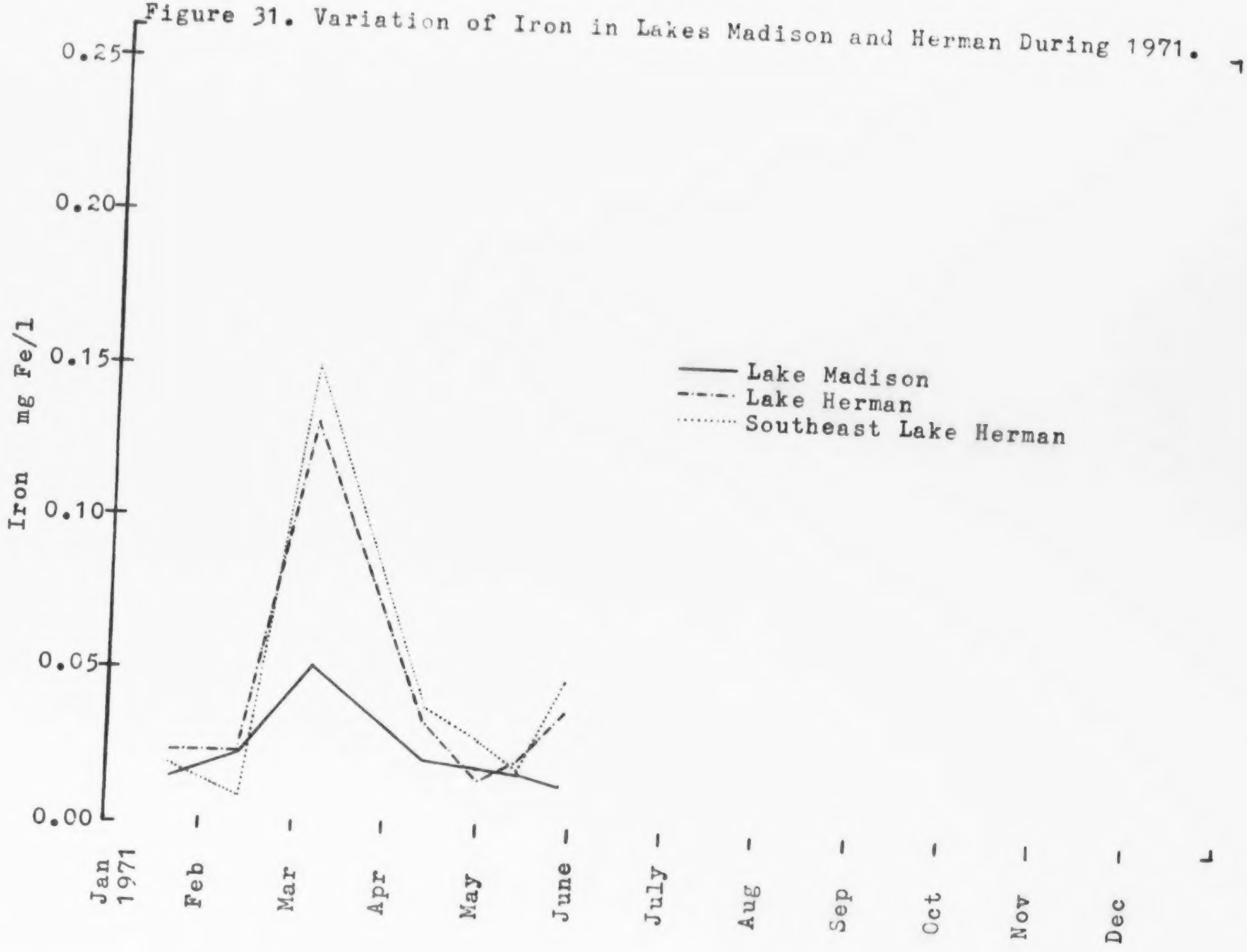


Figure 32. Variation of Manganese in Lakes Madison and Herman During 1970.

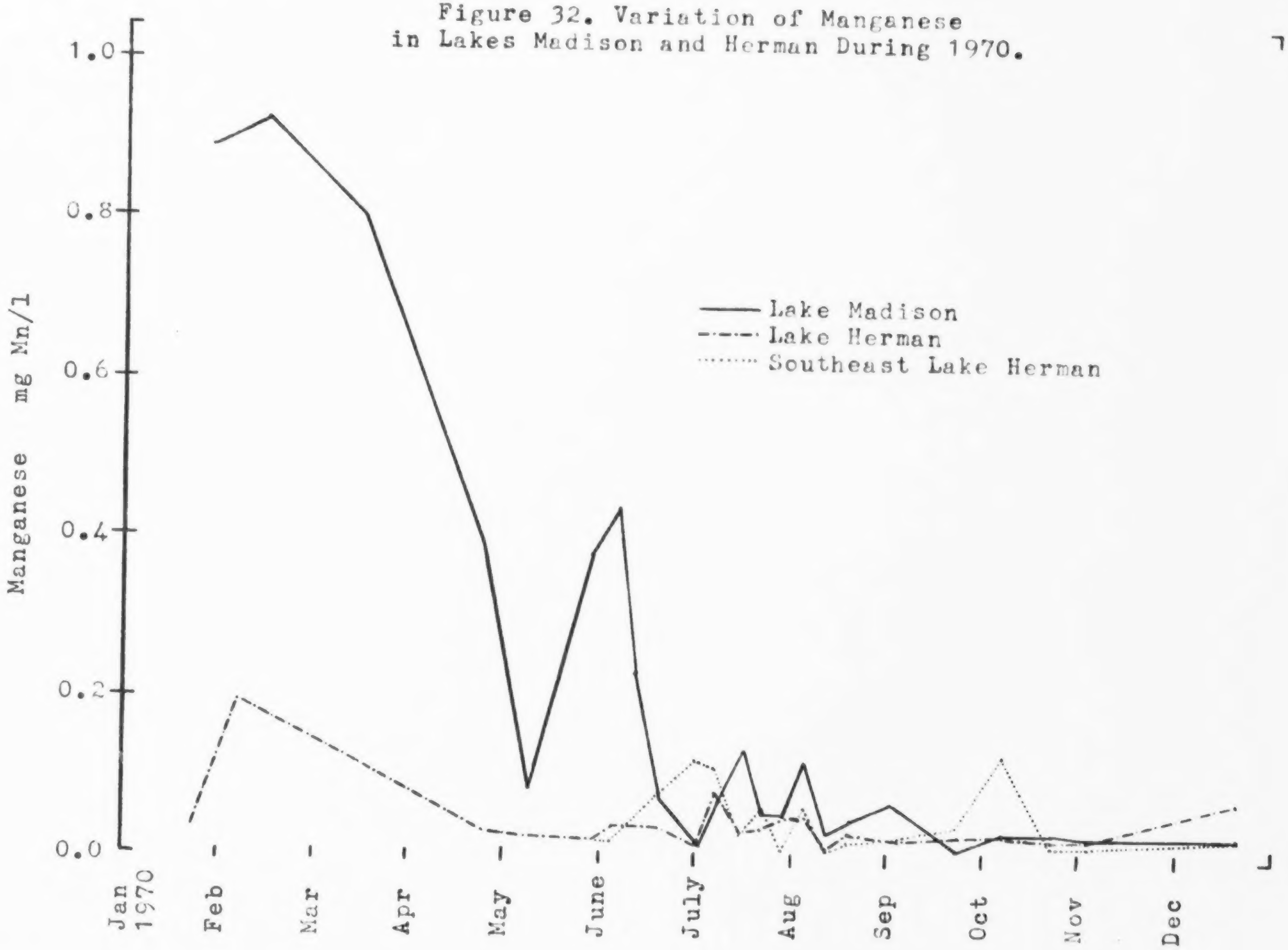
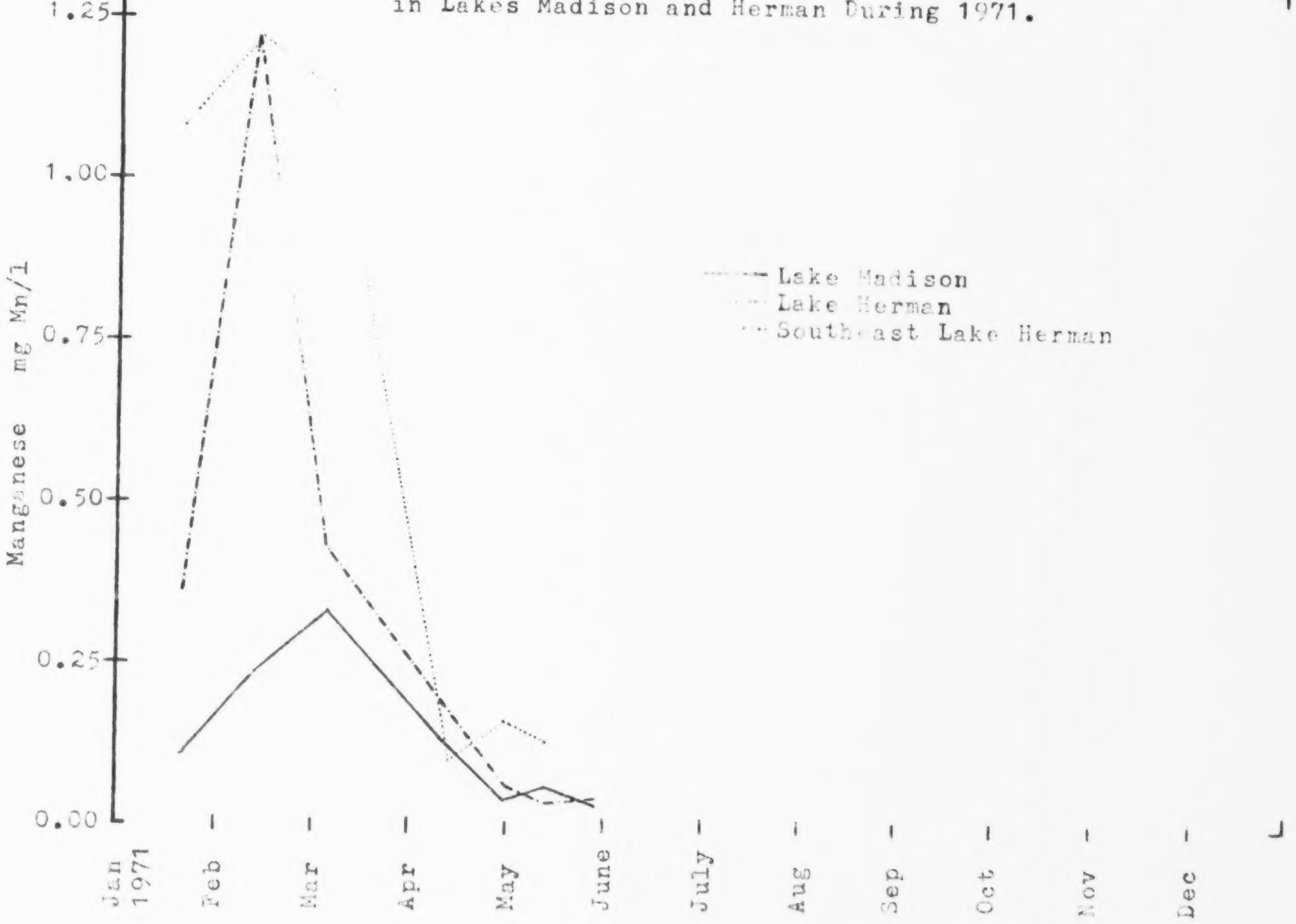


Figure 33. Variation of Manganese in Lakes Madison and Herman During 1971.



or after the spring run-offs. This maximum is followed by a decrease to a near minimum in early May and wide fluctuations during the summer and fall. The fluctuations do not coincide between the two lakes and are generally more pronounced in Lake Madison and Southeast Lake Herman.

Sodium and potassium follow the same pattern of seasonal change in both Lake Madison and Lake Herman. Figure 34 depicts potassium levels in the two lakes during 1970. The data graphed represent averages of the results listed in Appendices A and C. Since Southeast Lake Herman was not consistent with the remainder of the lake the last year of this project, it was graphed separately during that time. Sodium levels generally range from 100-140 mg/l Na in Lake Madison and 25-50 mg/l Na in Lake Herman. Potassium levels, however, are somewhat lower, ranging from 18-30 mg/l K in Lake Madison and from 12-25 mg/l K in Lake Herman. In both lakes and with both sodium and potassium there is a sharp decrease at the time of the spring run-off followed by an increase to a more normal level in April or May with a very slight rise during the summer and a greater rise in the fall and winter.

The results of the biological studies will now be discussed with reference to (1) variations in biota among the standard sampling sites in each lake, (2) variations in biota at different seasons of the year, and (3) variations in biota between the two lakes.

## Planktonic Algae in Lake Madison and Lake Herman

**The Green Algae and Euglenoids.** Euglenoids and green algae were not significantly abundant in either Lake Madison or Lake Herman during the summer or fall months. In Lake Madison, very light blooms of euglenoids and green algae occurred from the middle of March to early May during 1970 and 1971. The euglenoids contributed significantly to these light blooms. Species of *Euglena* were the most abundant, but *Phacus* sp. was occasionally recorded. Among the greens, species of *Scenedesmus* were the most abundant in the 1970 bloom, while species of *Chlamydomonas* contributed more to the bloom in 1971 than any other group. Other greens present in Lake Madison during the spring, summer and fall included species of *Pediastrum*, *Actinastrum*, *Ankistrodesmus*, *Coelastrum* and *Sphaerocystis*.

Slight increases in green algae occurred sporadically in Lake Herman during the spring, summer, and fall months, but these increases were brief and never contributed significantly to the algal blooms. Species of *Ankistrodesmus* were the most abundant of the greens and were found each year, 1968-1971. Other greens that were present, but on a very sporadic basis, included species of *Actinastrum*, *Cosmarium*, *Eudorina*, *Pediastrum*, *Scenedesmus*, *Selenastrum*, and *Sphaerocystis*. Euglenoids were essentially nonexistent in Lake Herman.

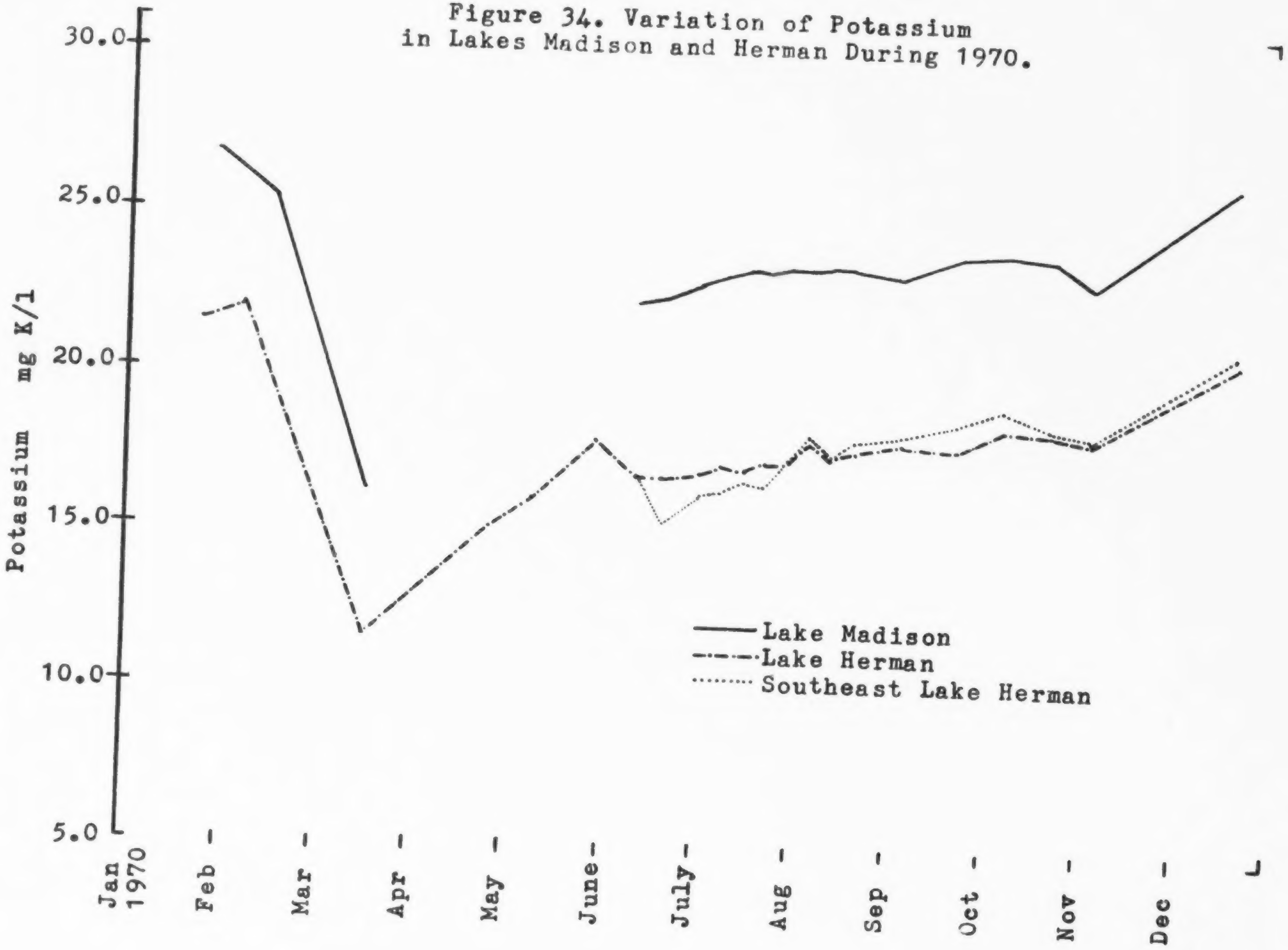


Figure 34. Variation of Potassium in Lakes Madison and Herman During 1970.

Blue-Green Algae in Lake Madison. In 1968, a blue-green bloom (10-100 organisms/ml) began in late May and early June (Figure 35) and became extremely dense (100 000 organisms/ml) in early July. Fluctuations in the blue-greens varied from 1,000 organisms/ml to 100,000 organisms/ml throughout the summer. The center of the lake had the greatest densities of blue-greens during the summer. The center and the west end (near the inlet of the lake) had the greatest fluctuations in populations of blue-green algae. A decrease in blue-greens throughout the lake began in early September and by the time an ice cover formed in November the blue-greens had almost disappeared.

In 1969, the bloom began in late May and June (Figure 36), as it had in 1968, and by July a dense bloom had developed. Although the fluctuations were less than those of 1968 (no densities over 19,000 organisms/ml occurred), the dense bloom persisted throughout the summer; and, once again, the center and west end had greater fluctuations in blue-greens than did the southeast end (near the lake's outlet). The population densities of blue-green algae during 1969 differed in one distinct way from that of 1968. The fall bloom in 1969 was still extremely dense when an ice cover was formed and persisted into the winter months. During the ensuing winter a total fish kill occurred in Lake Madison. The fish kill occurred quite early in the winter; dead fish were seen by ice fishermen as early as late December.

The blue-green bloom in 1970 (Figure 37) began in May, as it had in 1969, and reached its greatest density in July. However, the bloom was never as dense as it had been in the previous two years. An unusual decrease in the blue-green densities occurred in the middle of August. The decrease was preceded by low levels of phosphates during June and July (Figure 16), and the phosphates remained unusually low during the remainder of the summer. The only known change in factors affecting the chemistry of the lake was a decrease in phosphates from the sewage effluent of the city of Madison. A meat packing plant in the city of Madison was permanently closed early in 1970, and we believe there was a correlation between the closing of the meat packing plant and the relatively light blue-green bloom in the late summer and fall of 1970. A new bloom occurred in October, but rapidly decreased so that it was almost gone by the time an ice cover was formed in November. A fish kill did not occur during the ensuing winter.

The species of blue-green that was most abundant in the blooms in Lake Madison each summer was Aphanizomenon flos-aquae. Another blue-green Phormidium minnesotense was second in abundance in the blooms but was sporadic in occurrence. Other blue-greens which were present include species of Anabena, Coelosphaerium, Merismopedia, and Microcystis.

Diatoms in Lake Madison. The planktonic diatoms of Lake Madison usually had three distinct blooms each year (Figures 39 to 42). The first bloom began in March, reached its peak in late May and early June, and decreased to very low densities by the middle of July. A second bloom occurred in August and had declined by late August and early September.

Figure 35. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1968

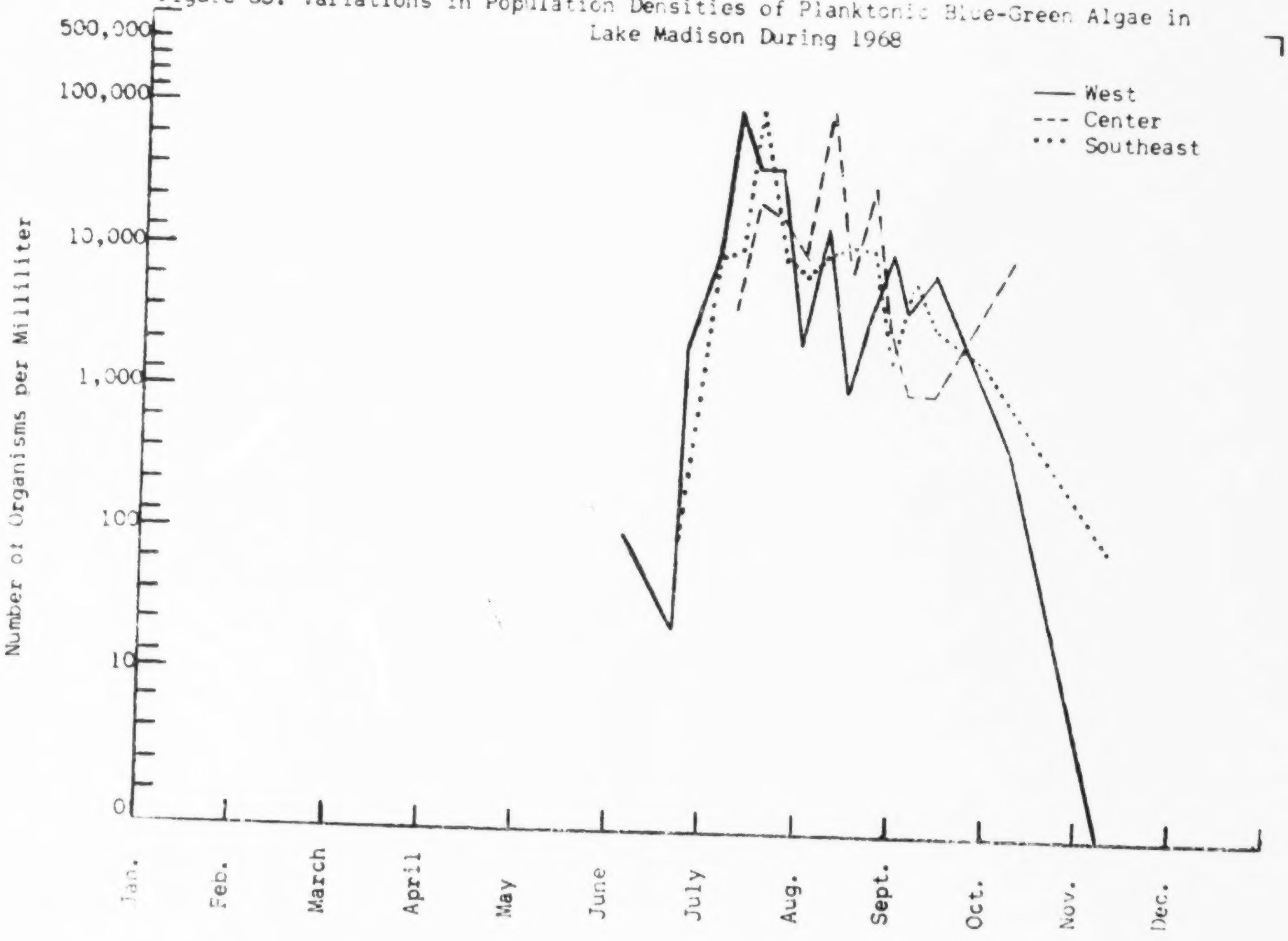


Figure 36. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1969

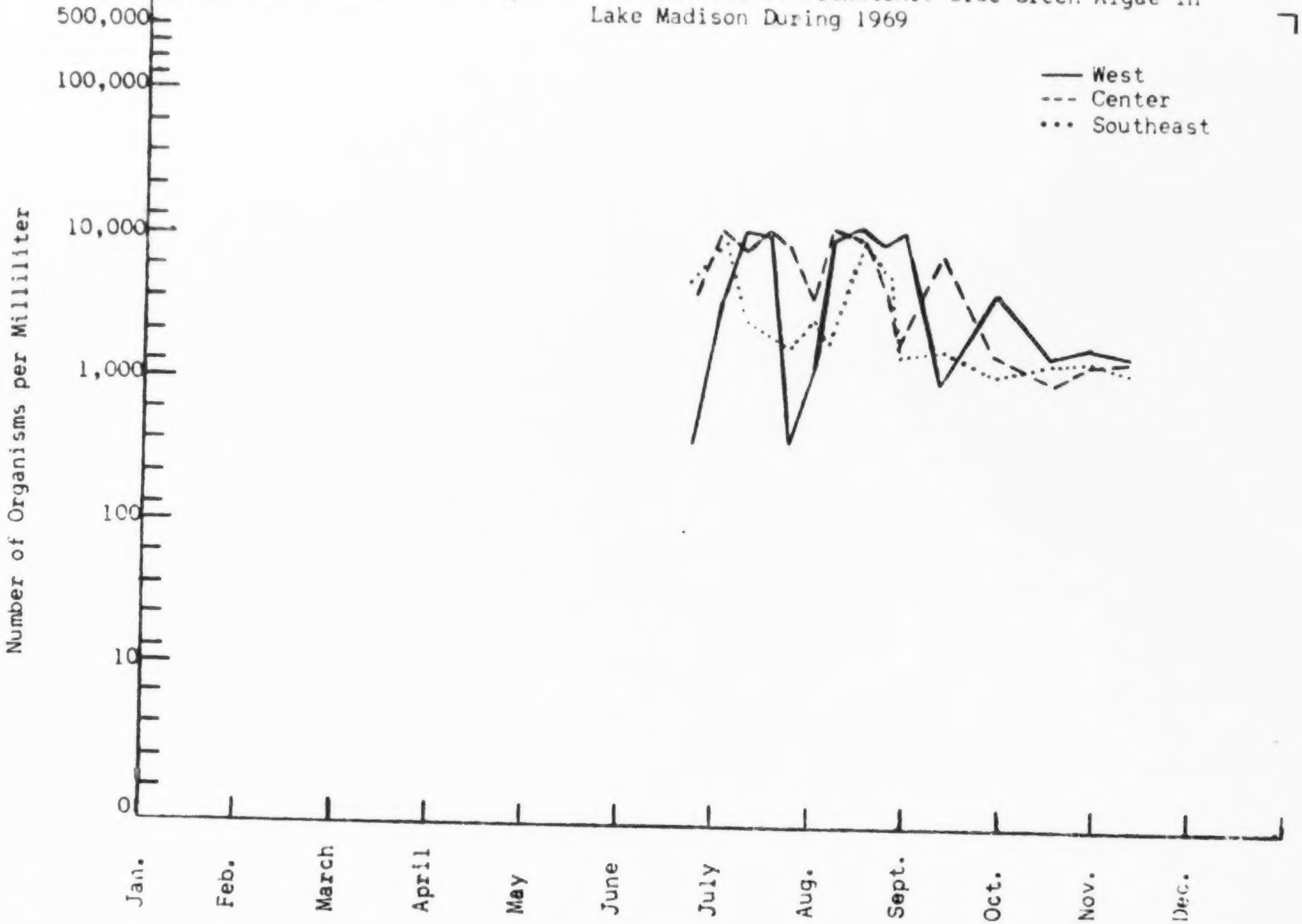


Figure 37. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1970

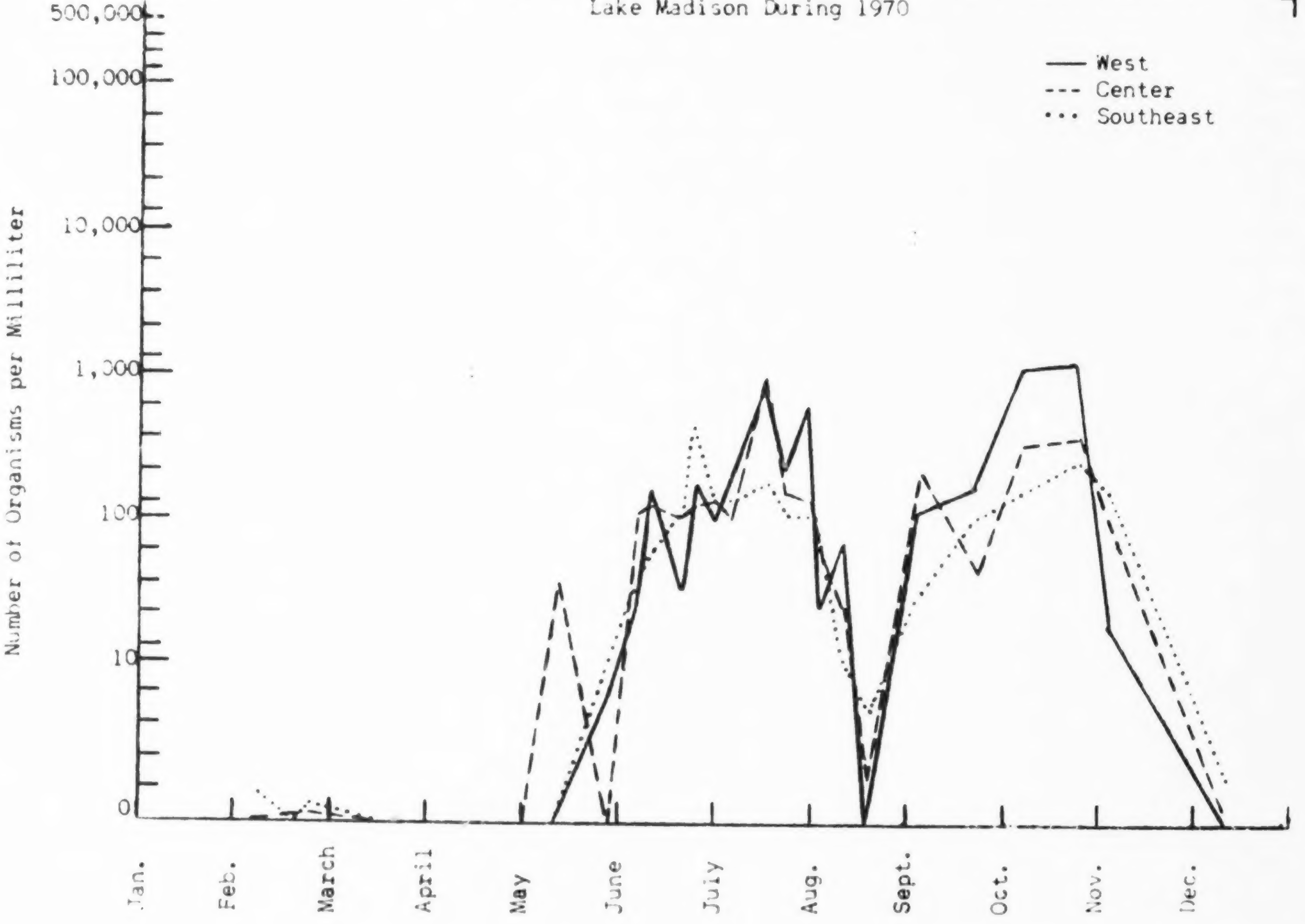


Figure 38. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Madison During 1971

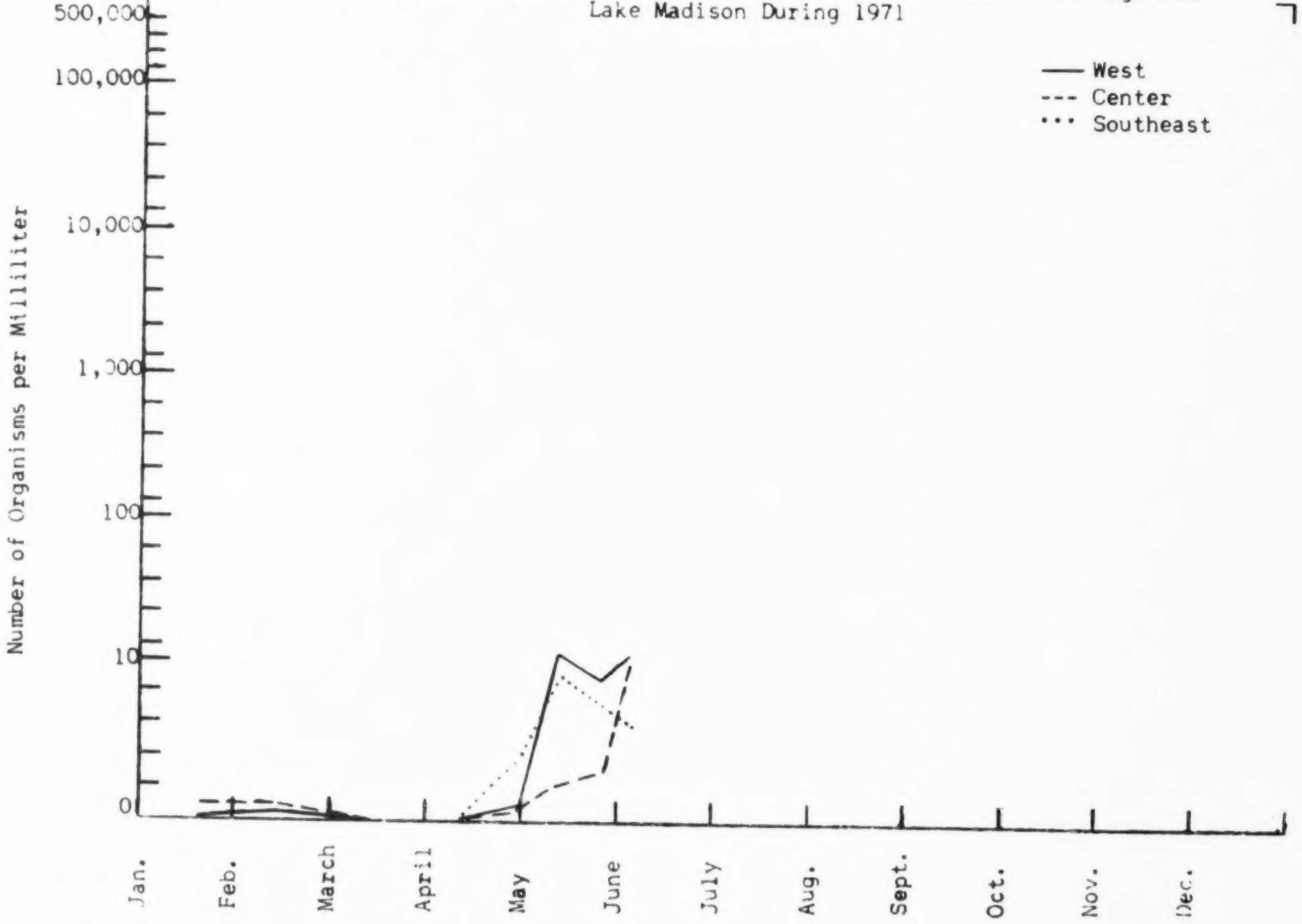


Figure 39. Variations in Population Densities of Planktonic Diatoms in Lake Madison During 1968

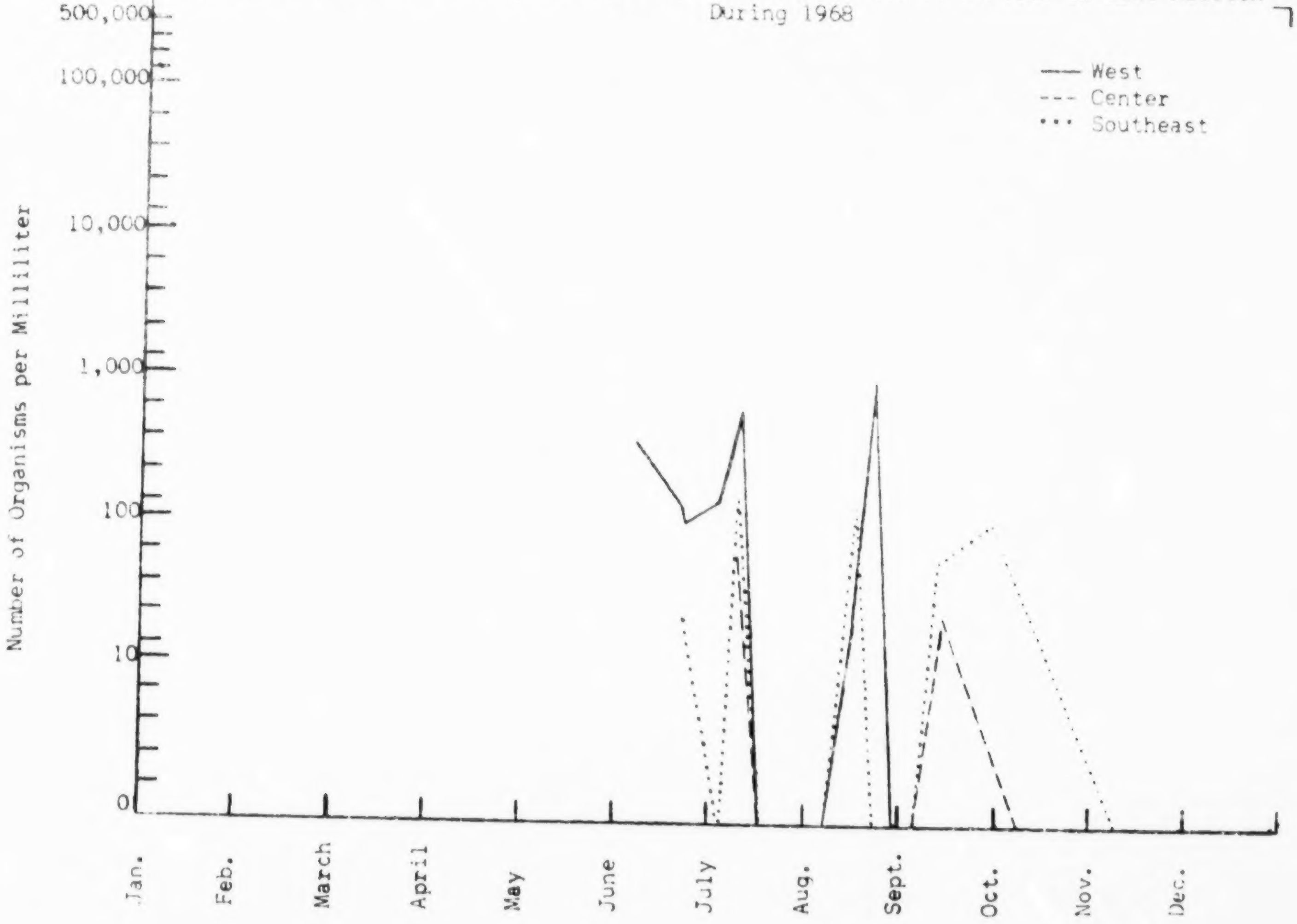


Figure 40. Variations in Population Densities of Planktonic Diatoms in Lake Madison During 1969

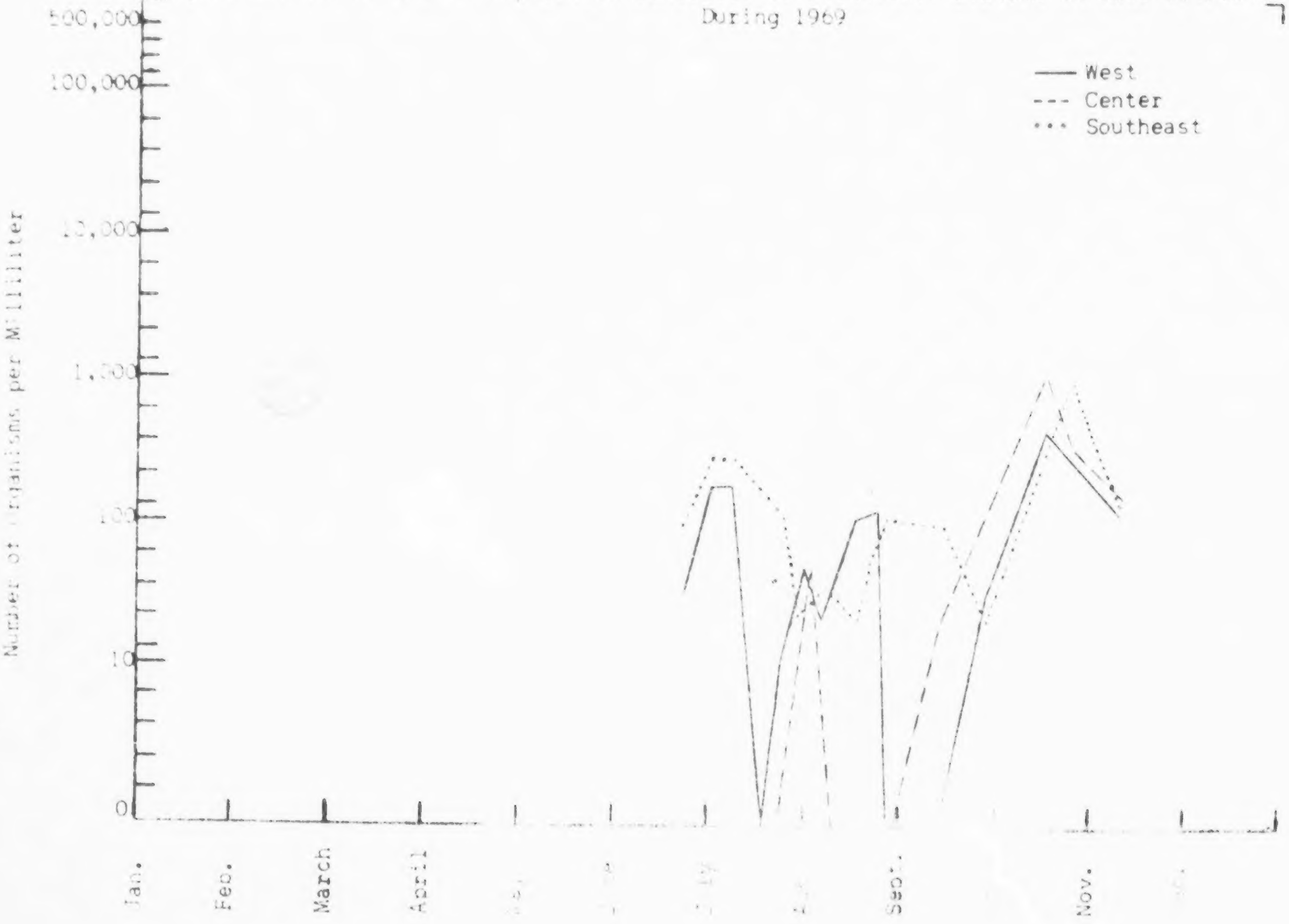


Figure 41. Variations in Population Densities of Planktonic Diatoms in Lake Madison During 1970

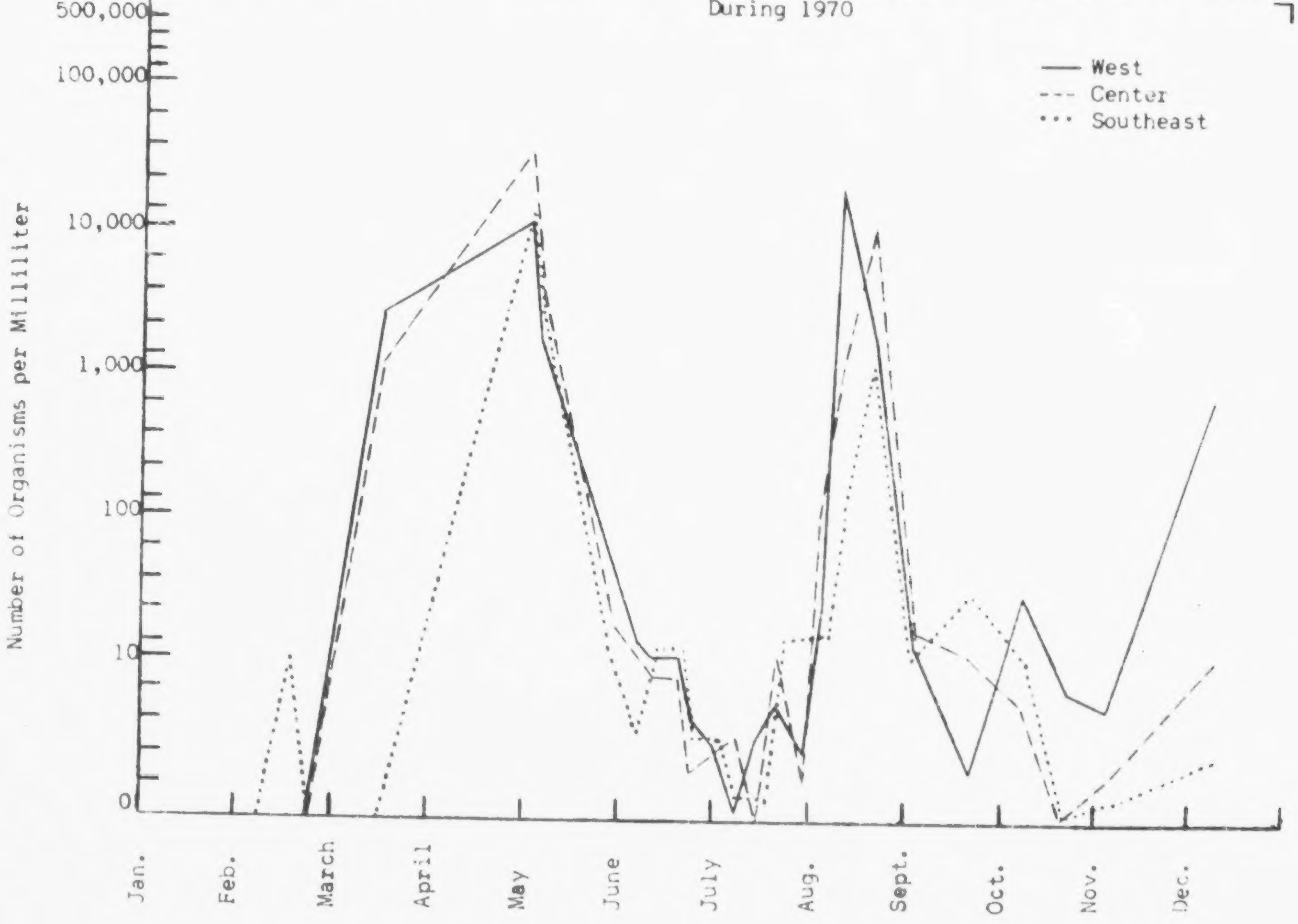


Figure 42. Variations of Population Densities of Planktonic Diatoms in Lake Madison During 1971

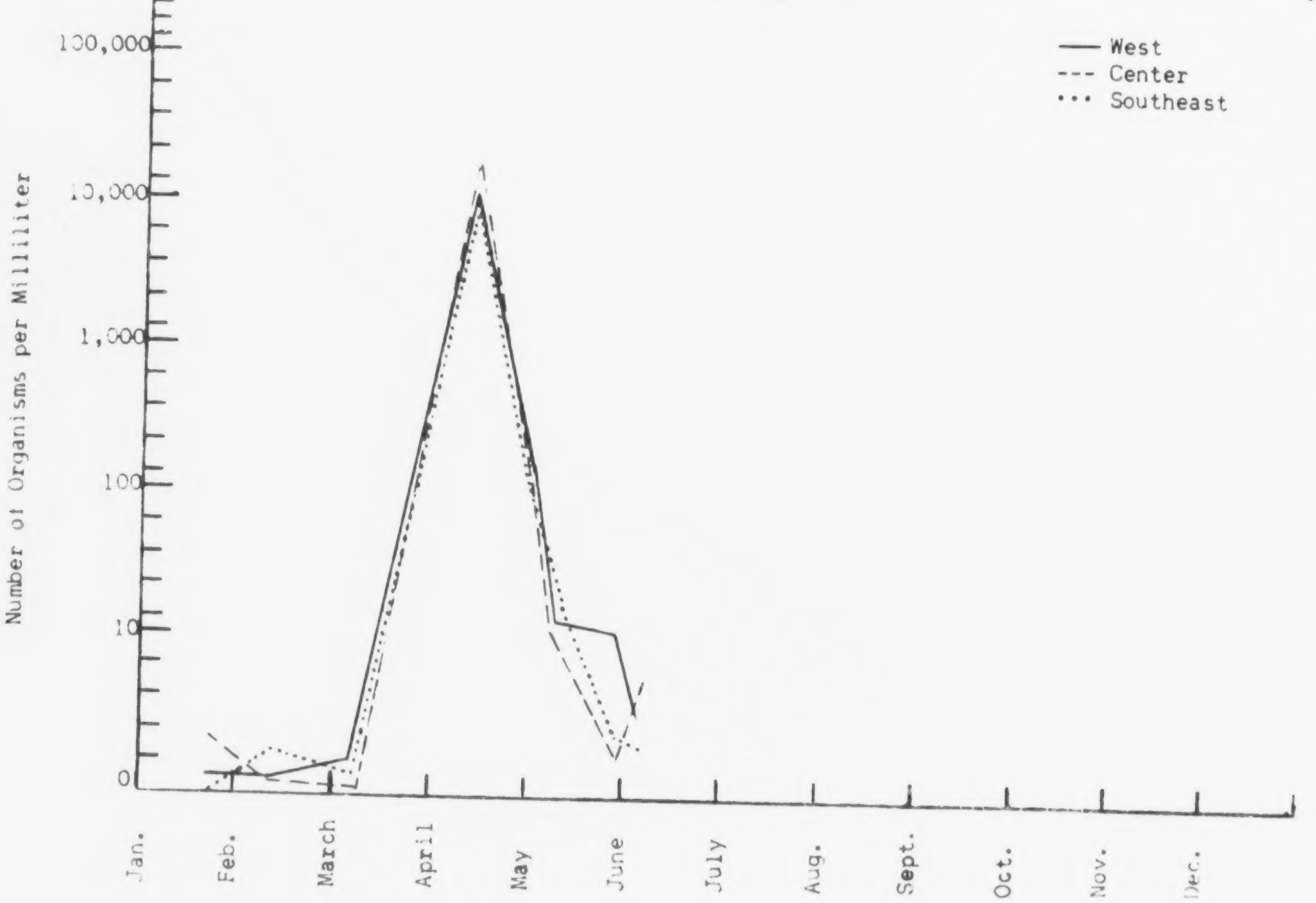
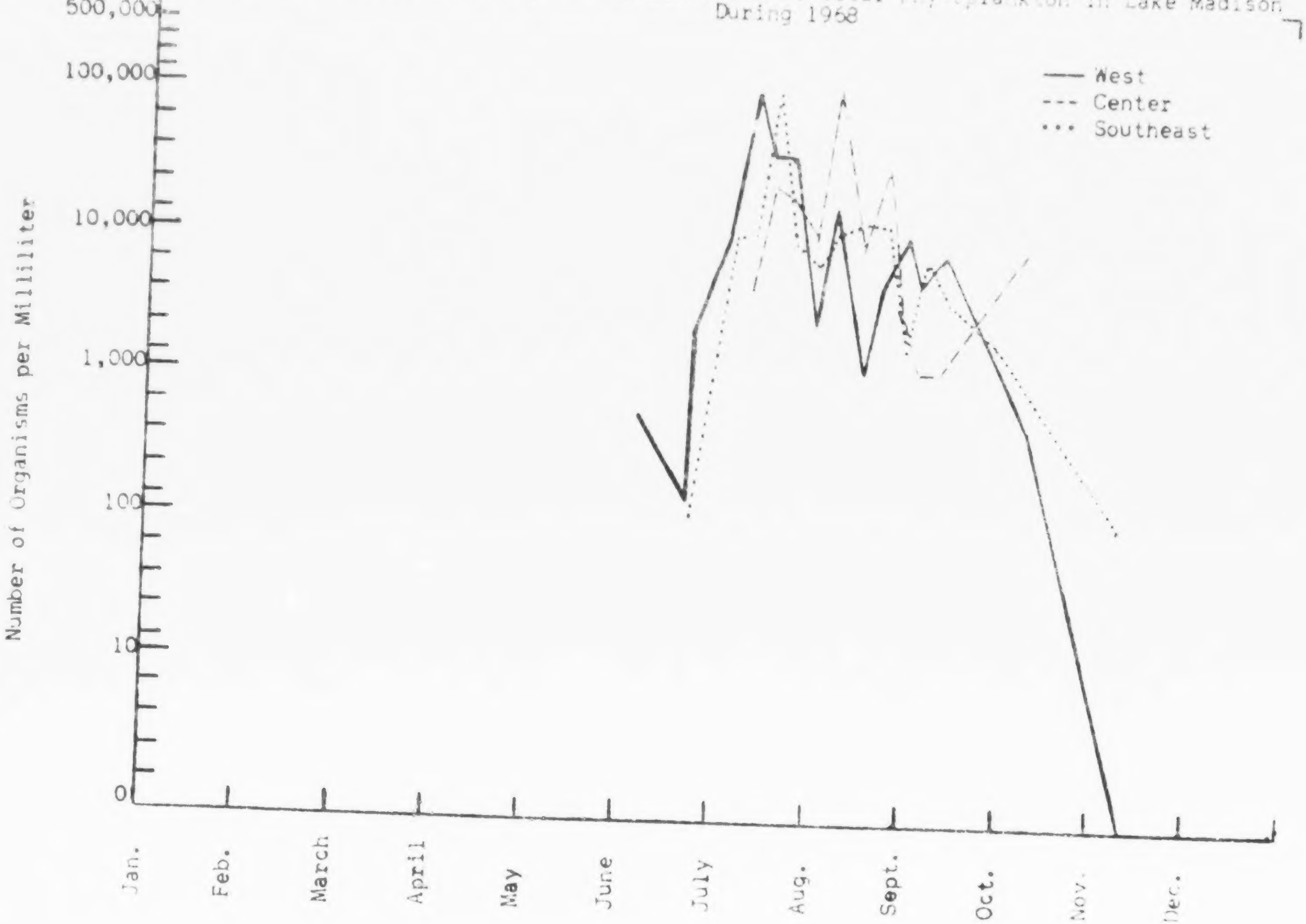


Figure 43. Variations in Population Densities of Total Phytoplankton in Lake Madison During 1968



[illegible] Population [illegible] Plankton [illegible]
During [illegible]

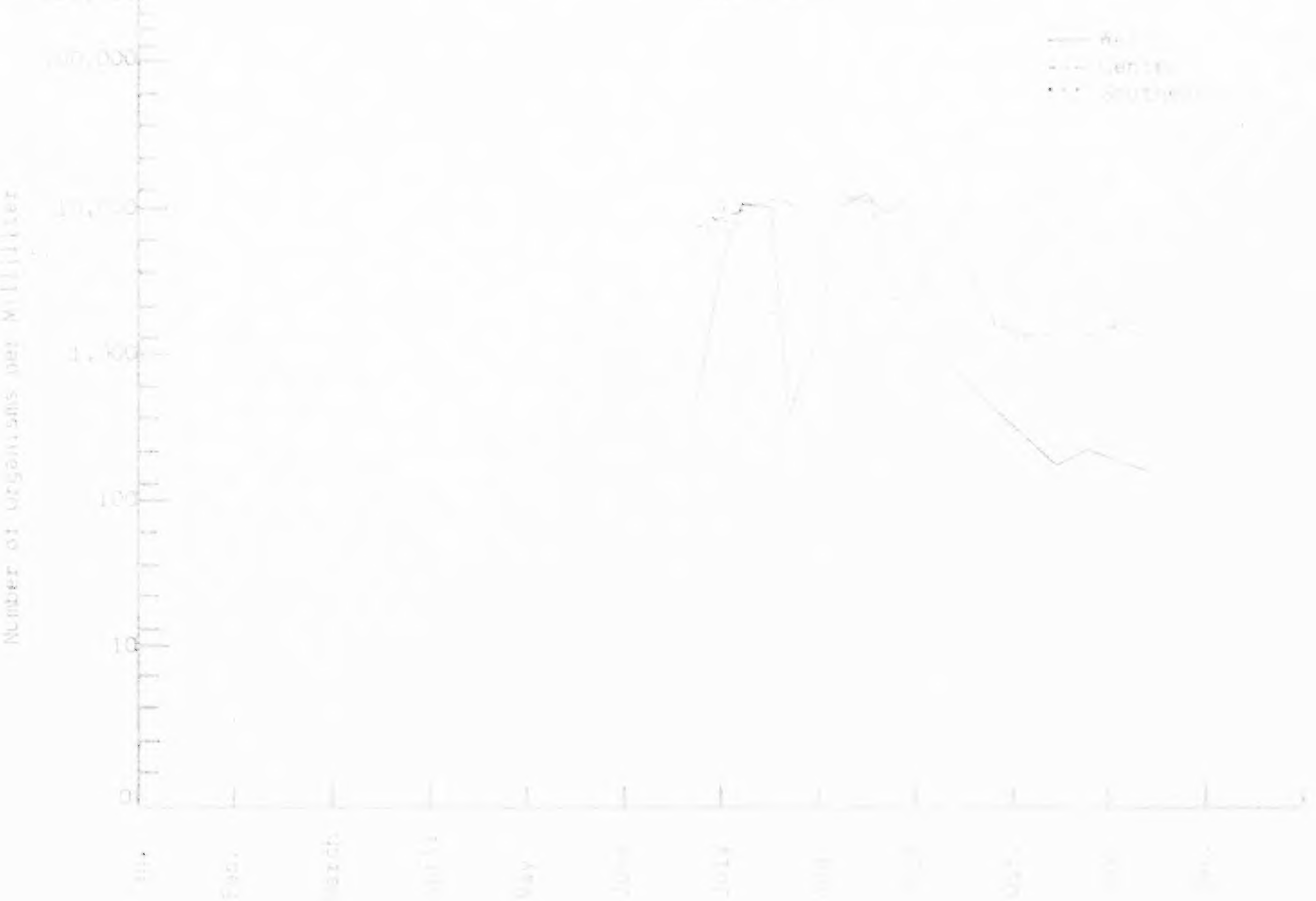


Figure 45. Variations in Population Densities of Total Phytoplankton in Lake Madison During 1970

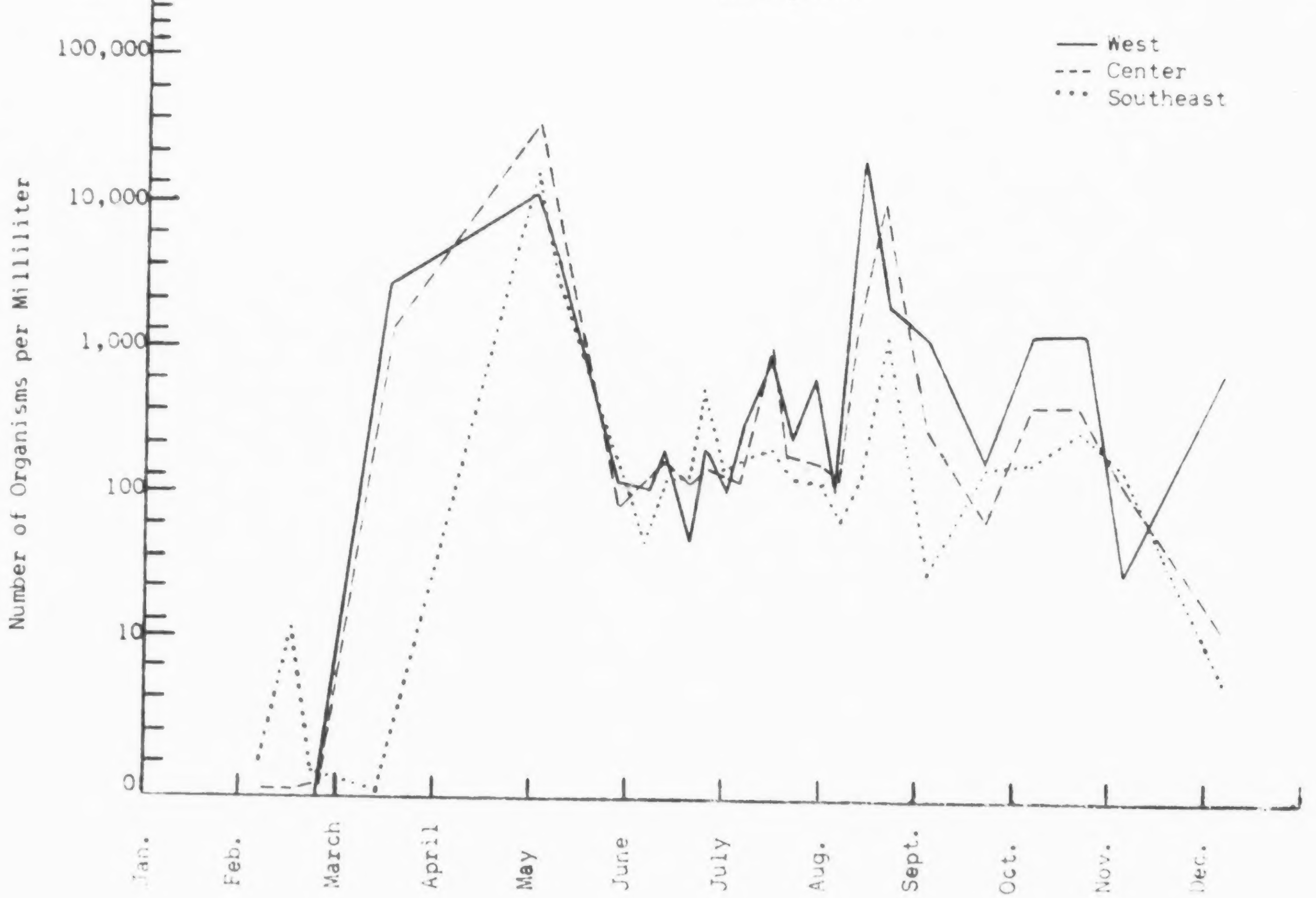
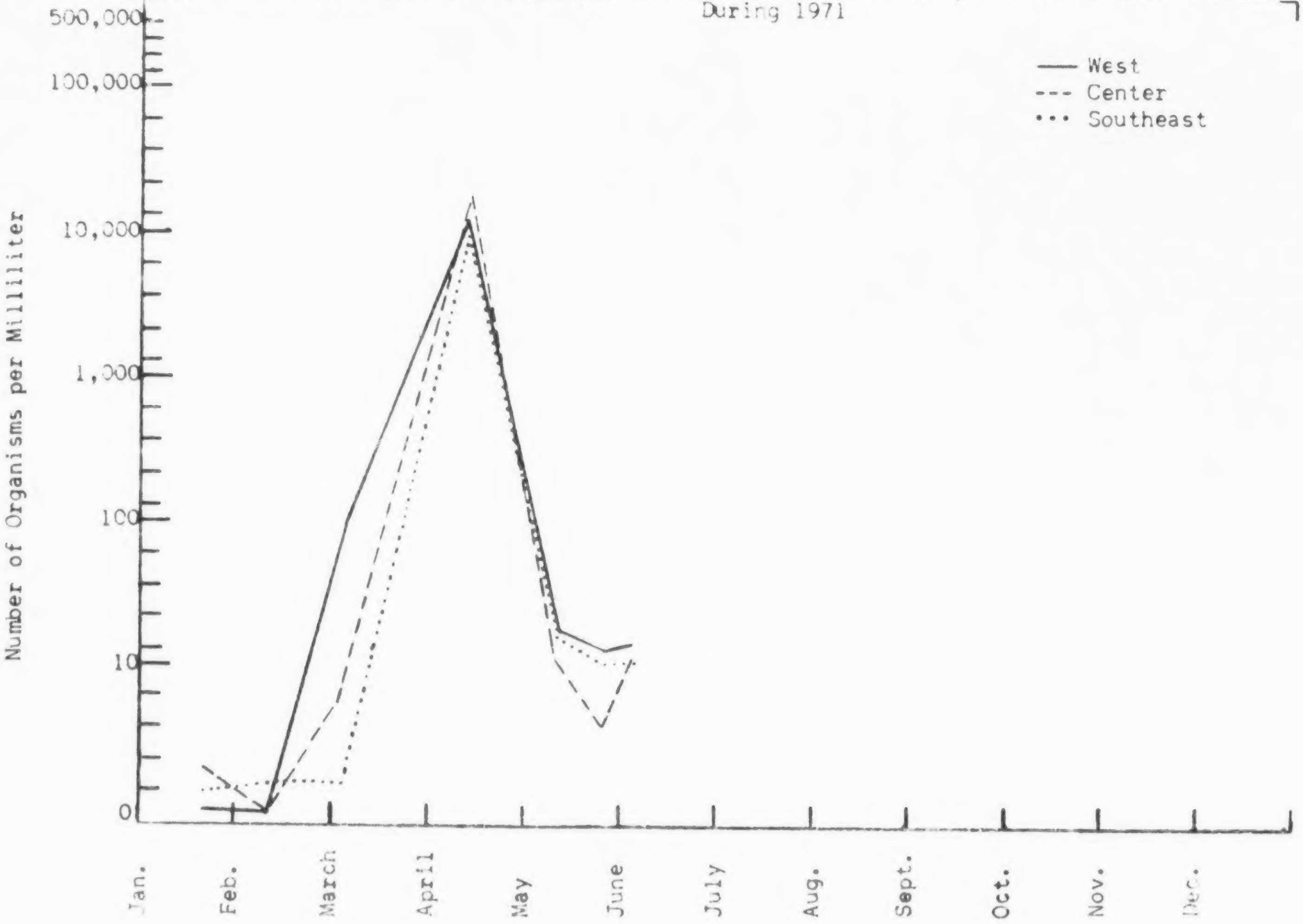


Figure 4a. Variations in Population Densities of Total Phytoplankton in Lake Madison During 1971



A third bloom occurred each fall, but varied more in its time of occurrence than did the first two blooms. The third bloom in 1968 and 1969 (Figures 39 and 40) occurred in September and had declined by November. The third bloom in 1970 (Figure 41) occurred mainly in November and December. There was only one significant difference between collection sites. In 1969 (Figure 40), three blooms occurred in all parts of the lake, but the decrease in diatom densities between the blooms was not nearly as great in the southeast part of the lake as it was throughout the rest of the lake. This occurred only during 1969.

Species of *Cyclotella* dominated most of the diatom blooms during this study. This was especially true during 1970 and 1971 when the diatoms were the most numerous of the phytoplankton groups. Diatoms which were of secondary importance, but dominated some of the lighter blooms in 1968 and 1969, were species of *Nitzschia* and *Stephanodiscus*. Other diatoms included species of *Cocconeis*, *Fragilaris*. *Gomphonema*, *Melosira*, *Navicula*, *Pinnularia*, *Surirella* and *Synedra*.

### *Comparison of Blue-Greens and Diatoms in Lake Madison*

One interesting observation in a comparison of diatoms and blue-greens is the very high densities of blue-greens in the lake in 1968 and 1969. They frequently numbered from 2,000 to 65,000 organisms/ml during the main part of the bloom. The diatoms during these two years seldom numbered over 1,000 to 1,200 organisms/ml even at their greatest densities and were usually much less abundant. However, the blue-green densities in 1970 were very low, reaching a maximum count of only 1,817 organisms/ml during most of the summer. In contrast, the diatom population reached a density of 57,663 organisms/ml during the first diatom bloom in late April and were usually above 10,000 organisms/ml. The first diatom bloom in 1971 reached a maximum of nearly 29,000 organisms/ml. In contrast, the blue-green population densities were very low at the time.

*Blue-Green Algae in Lake Herman*. The blue-green bloom in Lake Herman during 1968 (Figures 47 and 48) reached its peak in August when 39,044 organisms/ml were present. The bloom declined rapidly in September and October and totaled less than 1,000 organisms/ml in early November, just prior to the formation of an ice cover. Fluctuations in densities between collection sites do not appear to be significant. Increases in population densities began first at the north end of the lake (near the main inlet) and progressed through the lake to the southeast corner. However, the greatest densities for all parts of the lake were approximately the same in late July and early August. The water depth in the lake was very low because of drought and during the ensuing winter a total fish kill occurred.

The greatest densities of blue-greens during 1969 occurred in July (Figures 49 and 50) when there were 1,036 organisms/ml. There was no significant blue-green bloom in 1969.

Figure 47. Variations of Population Densities of Planktonic Blue-Green Algae in Lake Herman 1960

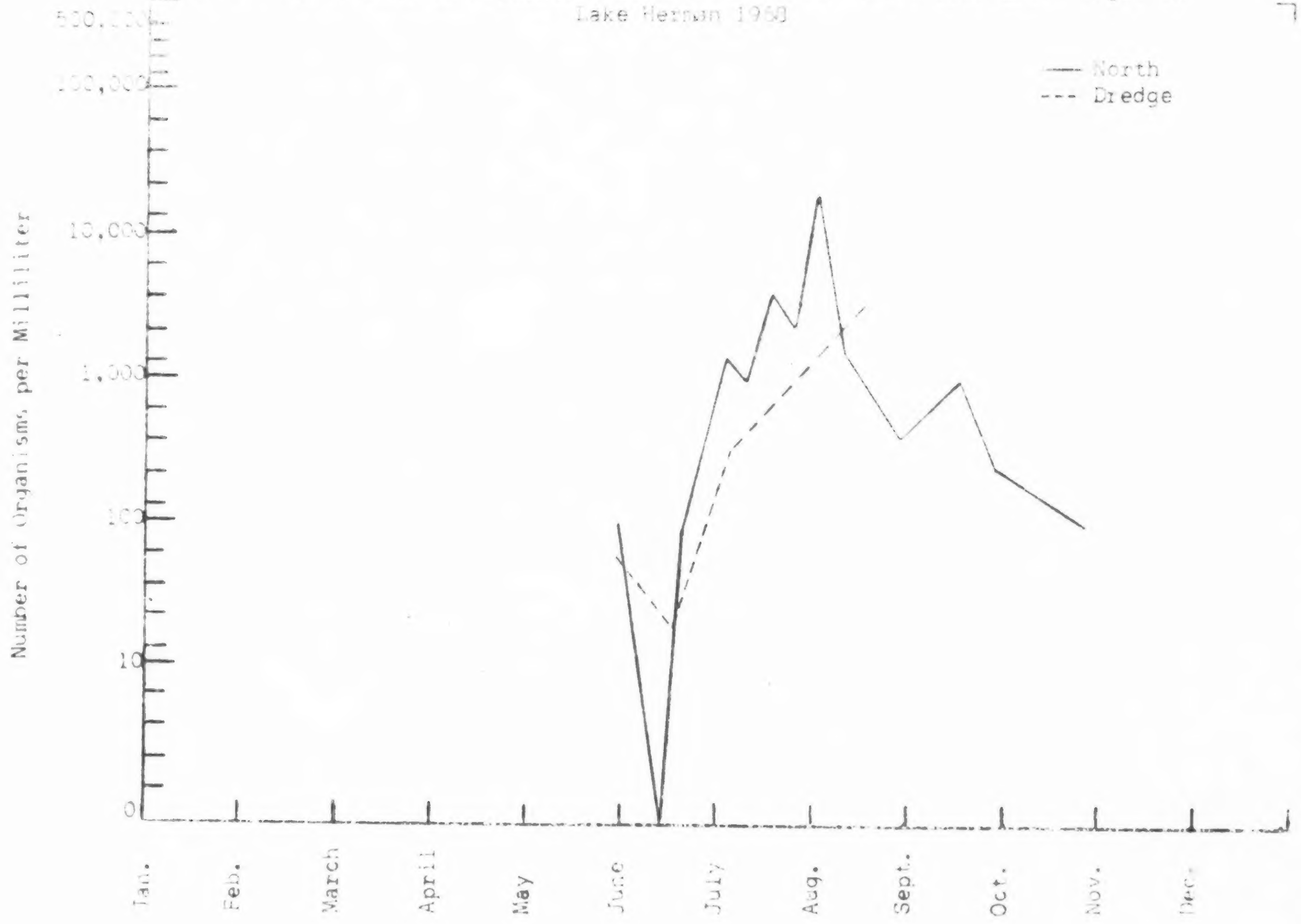


Figure 48. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1968

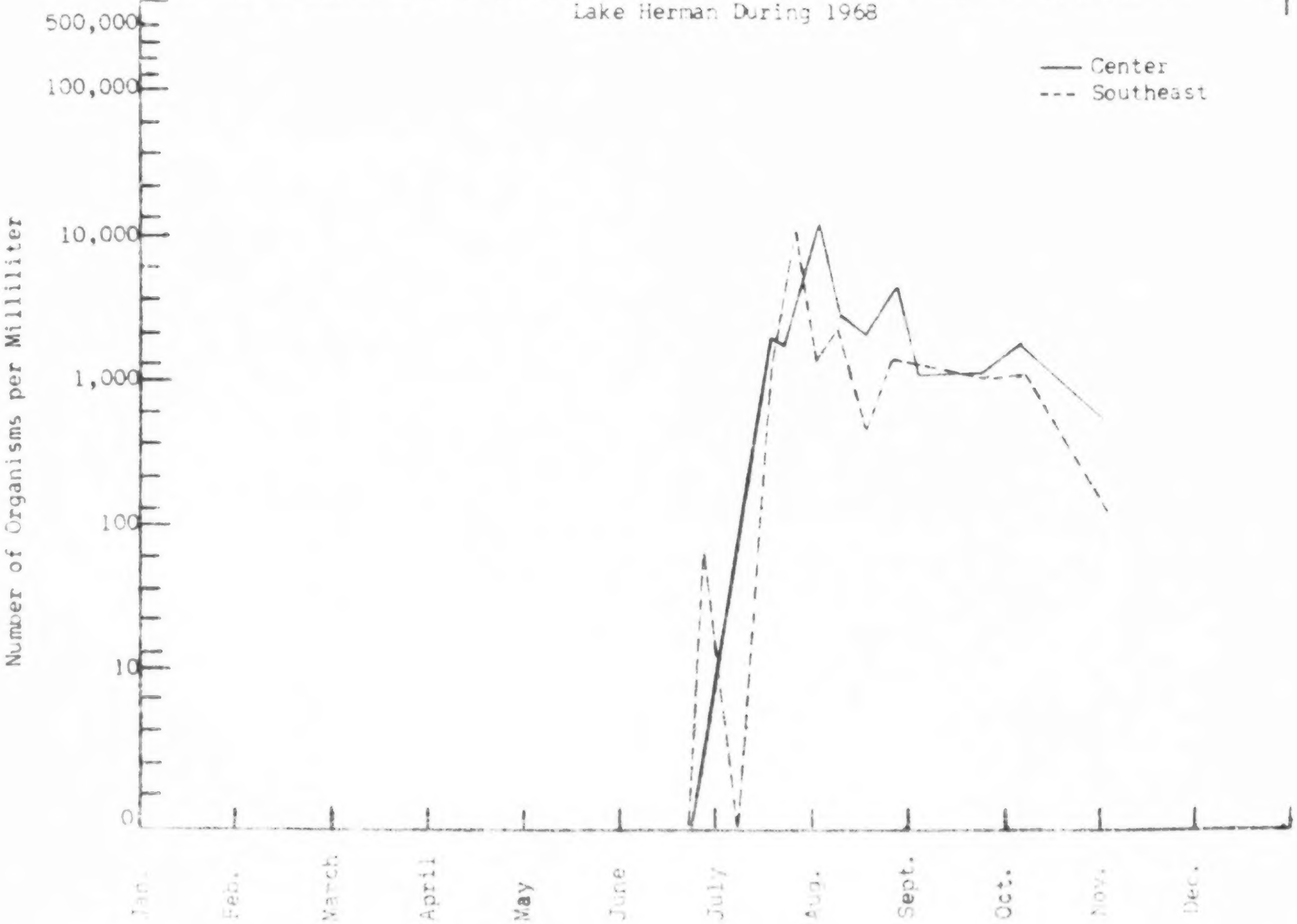


Figure 49. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1969

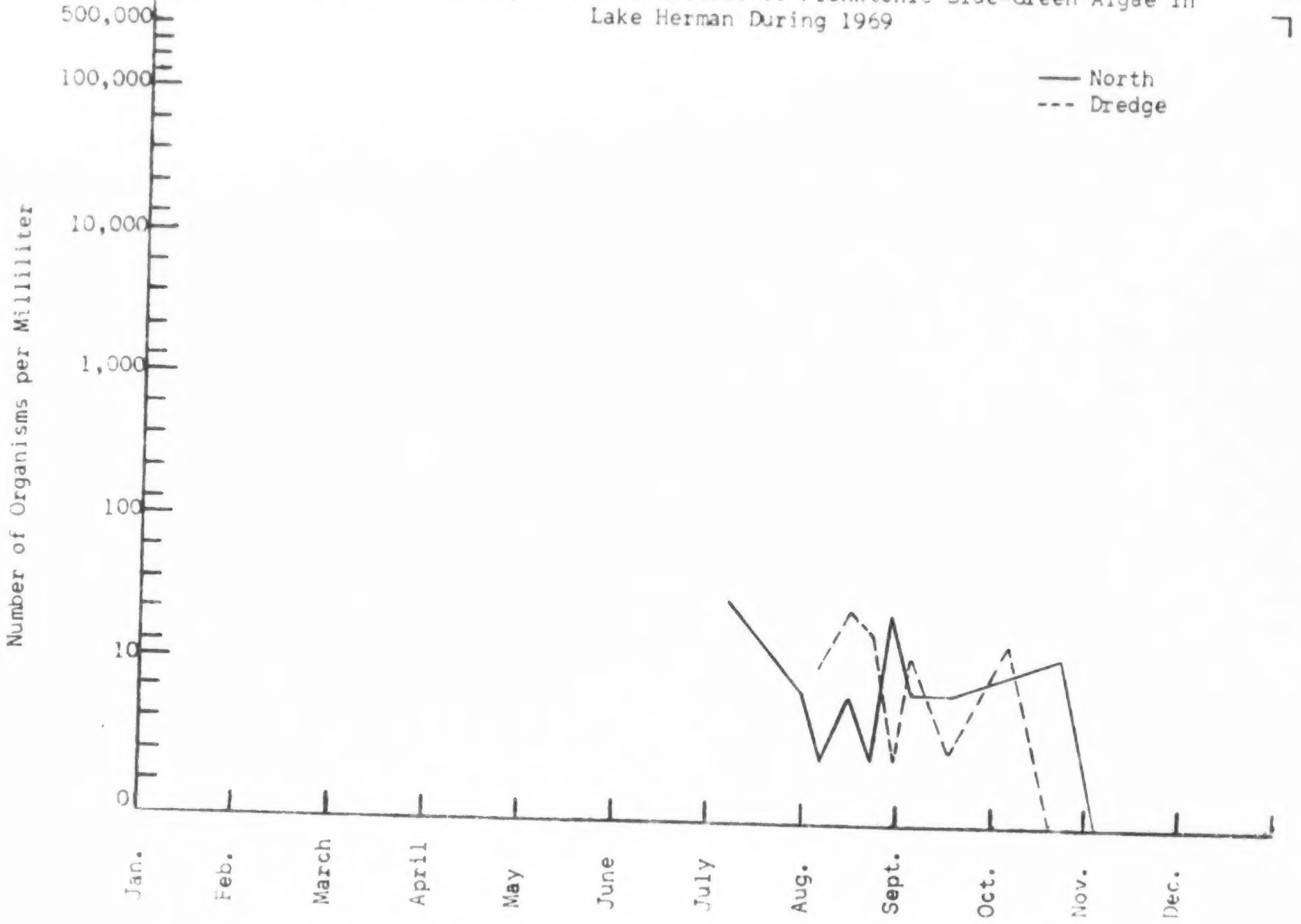


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Figure 51. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1970

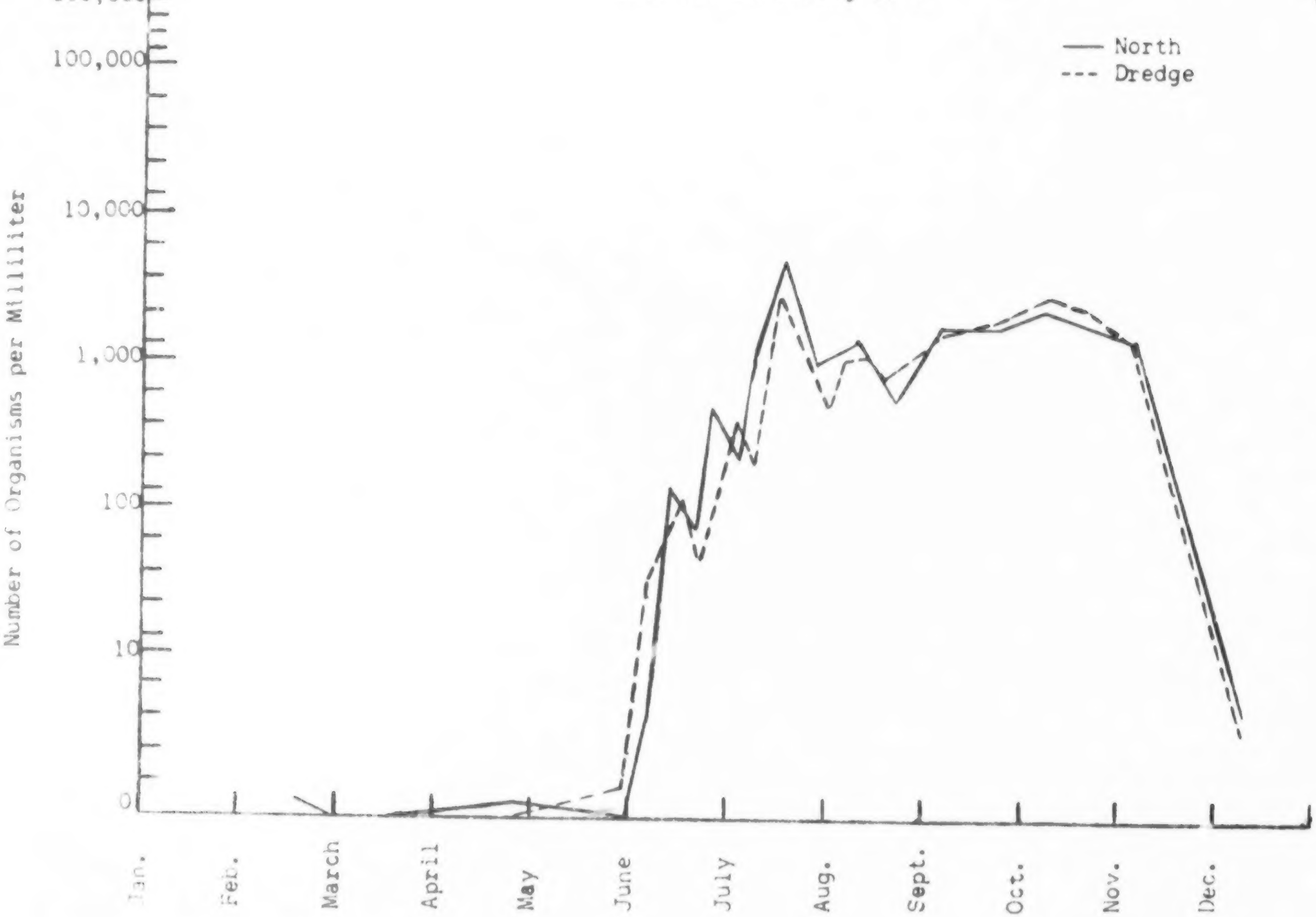


Figure 52. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1970

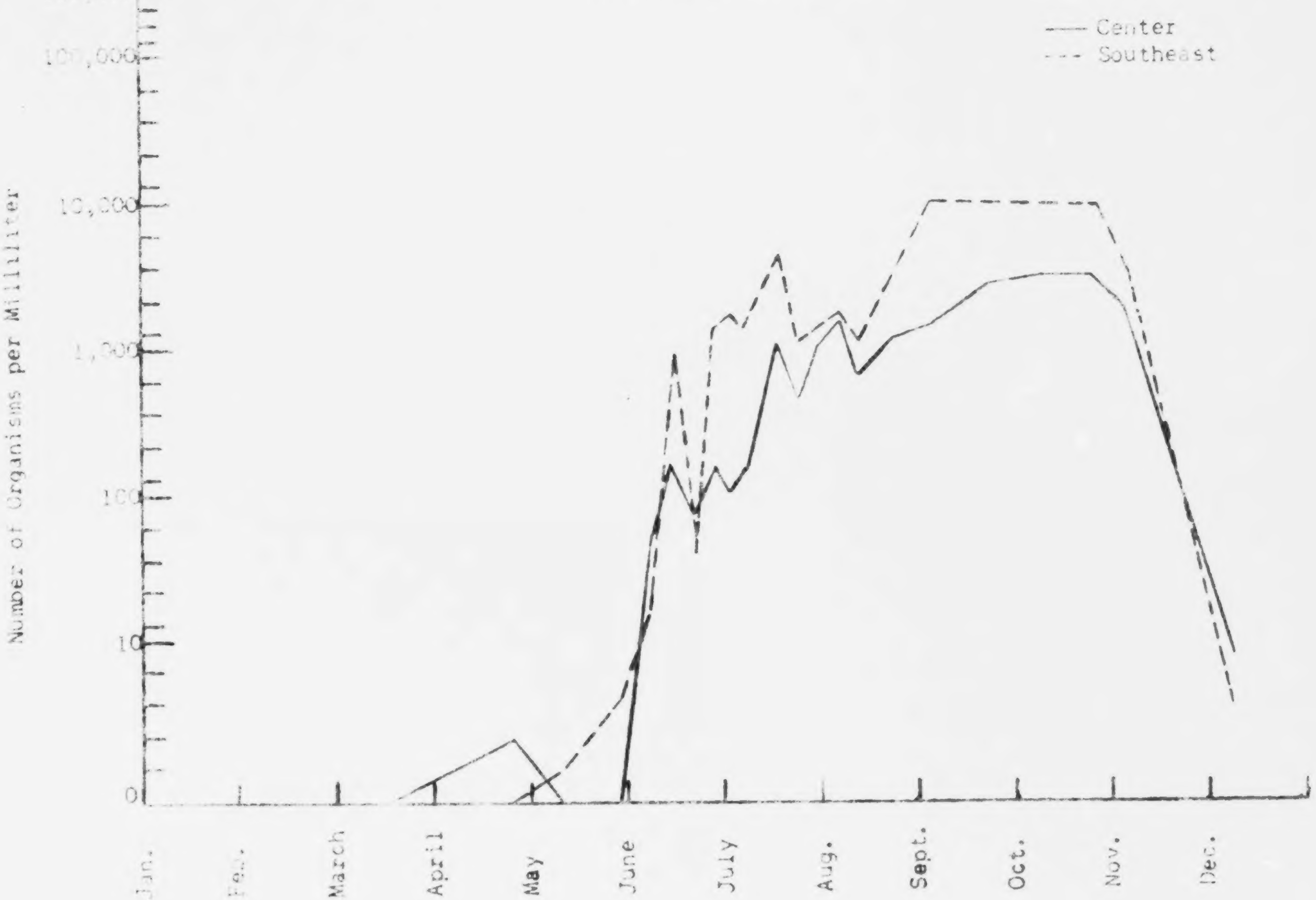


Figure 53. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1971

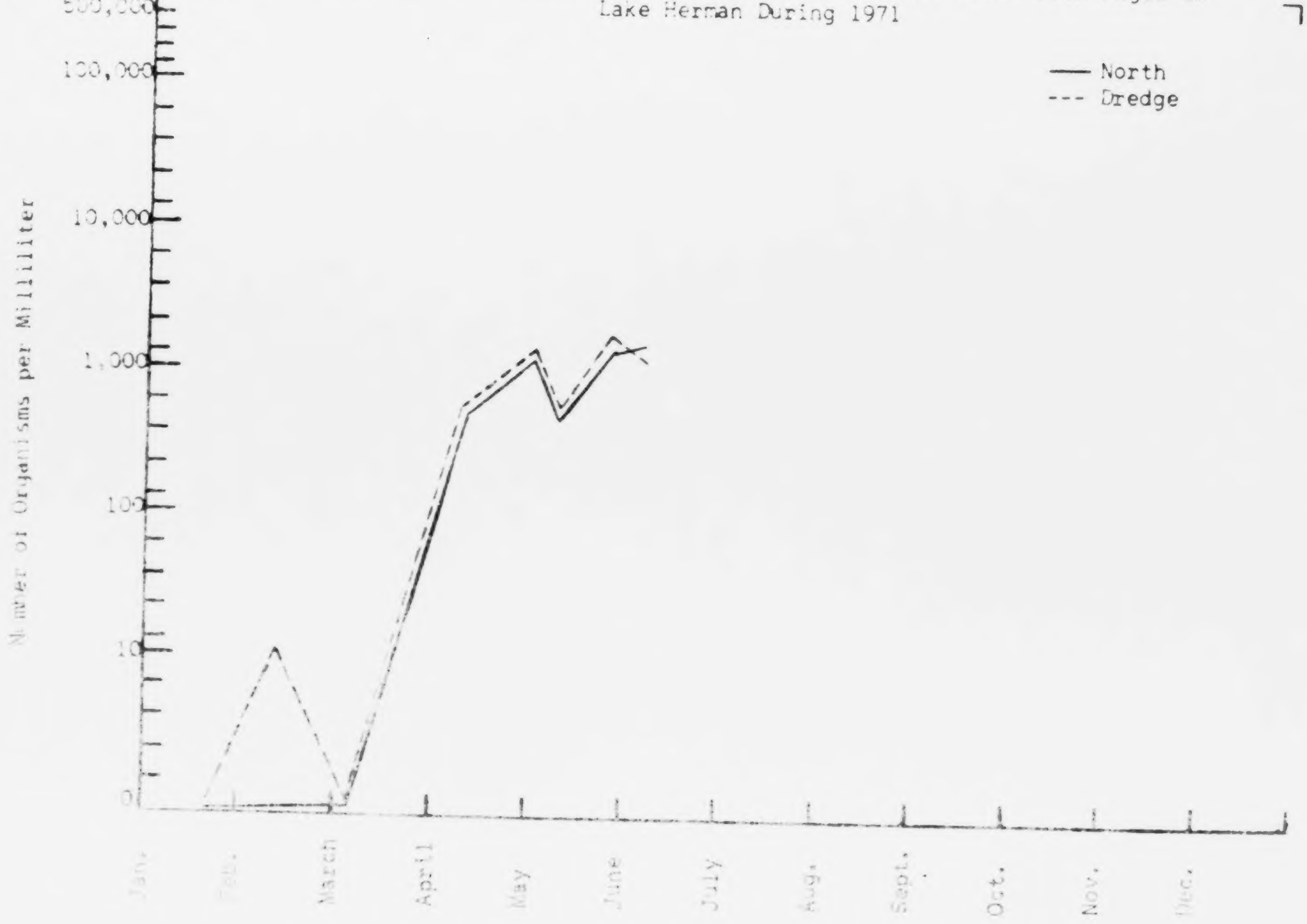
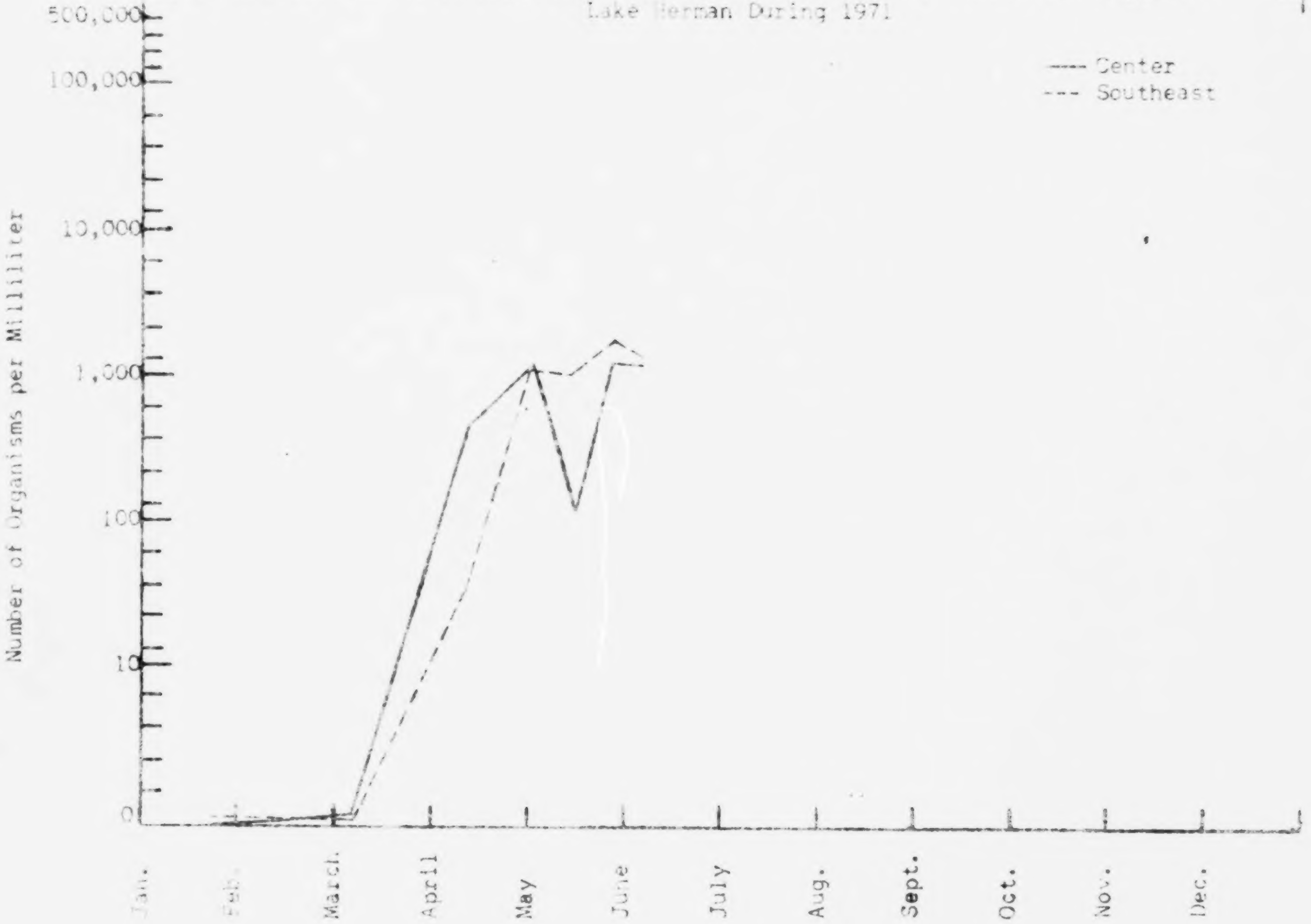


Figure 54. Variations in Population Densities of Planktonic Blue-Green Algae in Lake Herman During 1971



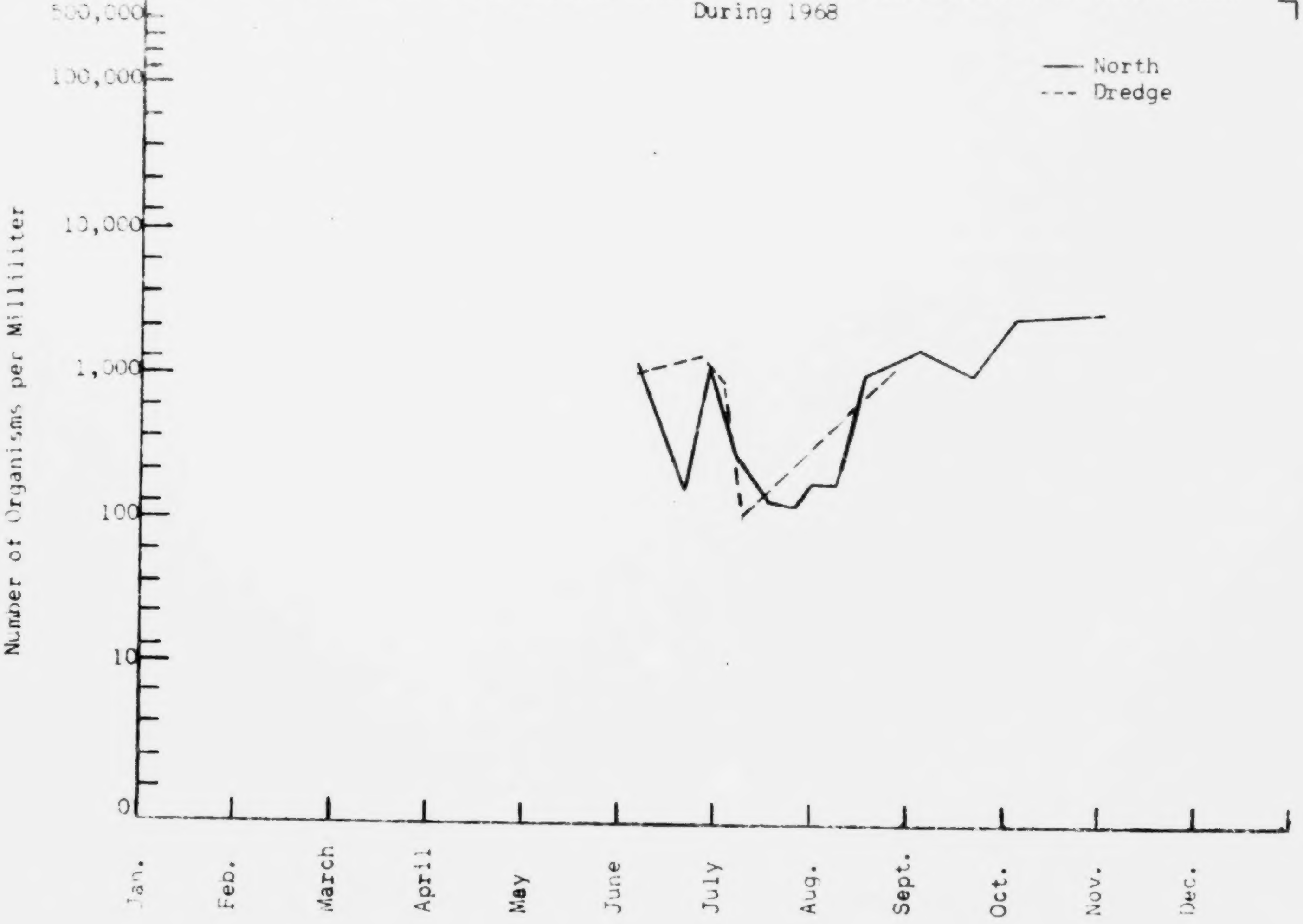


Figure 55. Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1968

Figure 56. Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1968

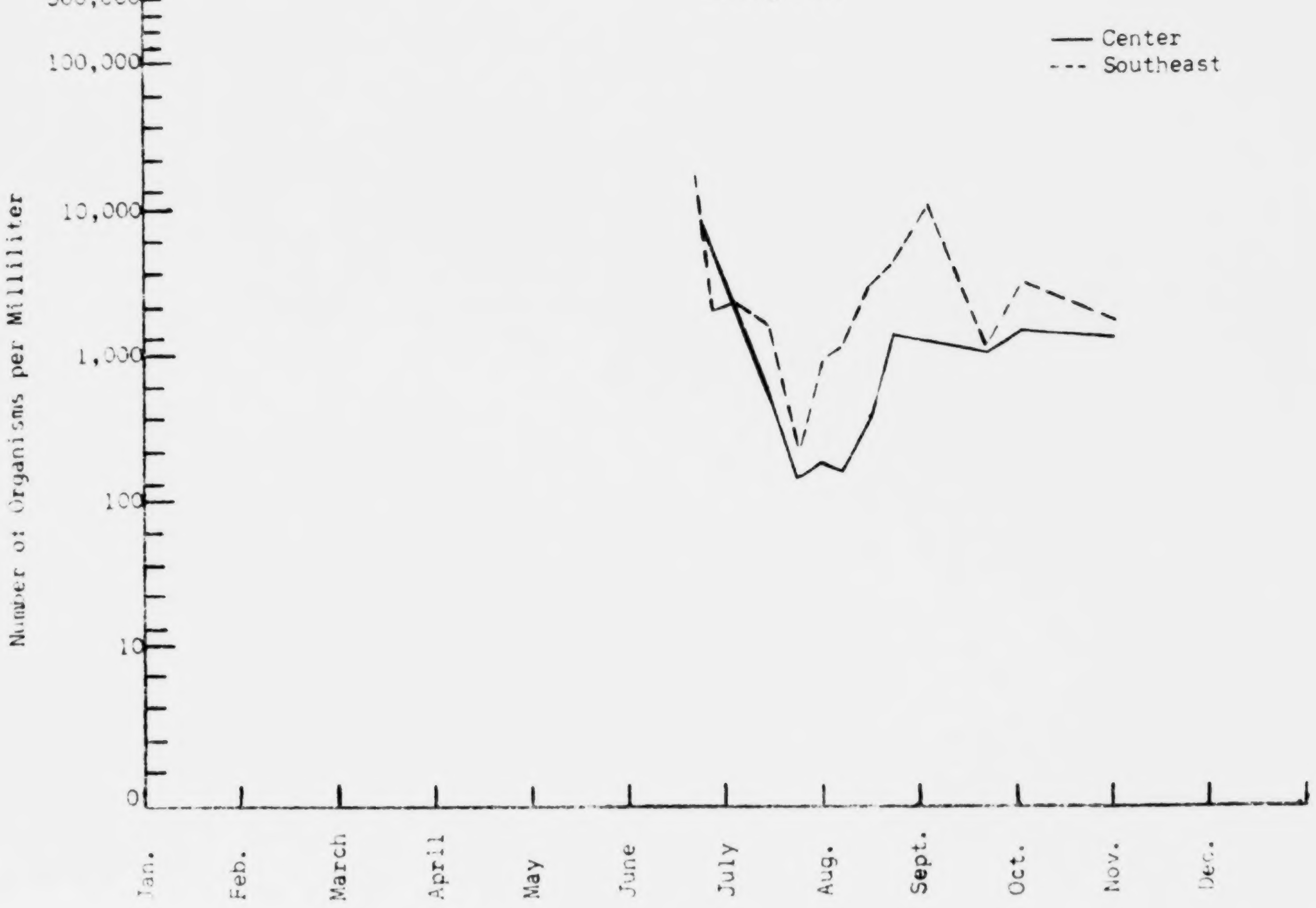


Figure 37. Variations in Population Densities of Planktonic Diatoms in Lake Vernon During 1969

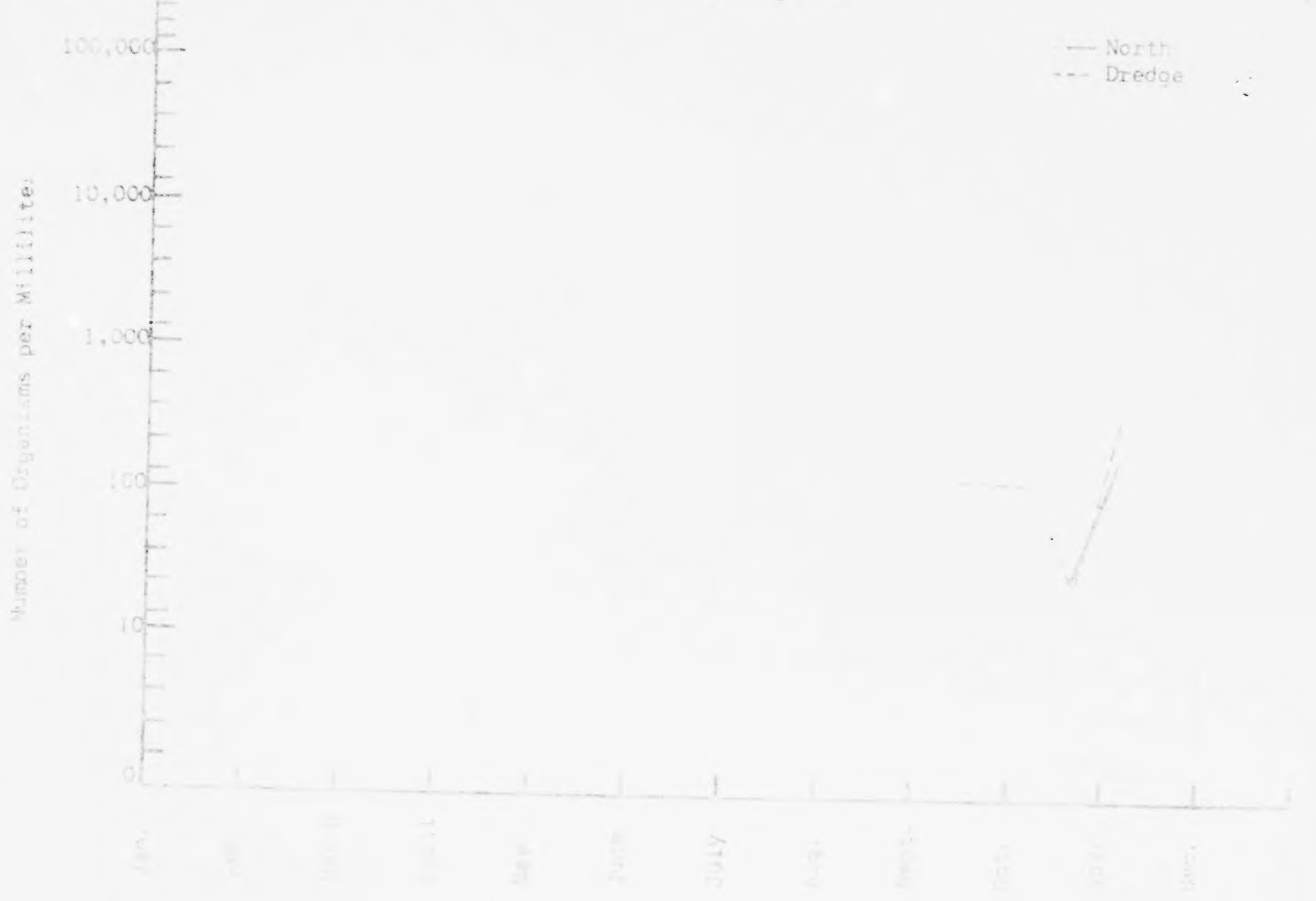


Figure 12. [illegible] Population Densities of Planktonic Diatoms in Lake Norman, August 1969

Figure 59. Variations in Population Densities of Planktonic Diatoms in Lake Herman
During 1970

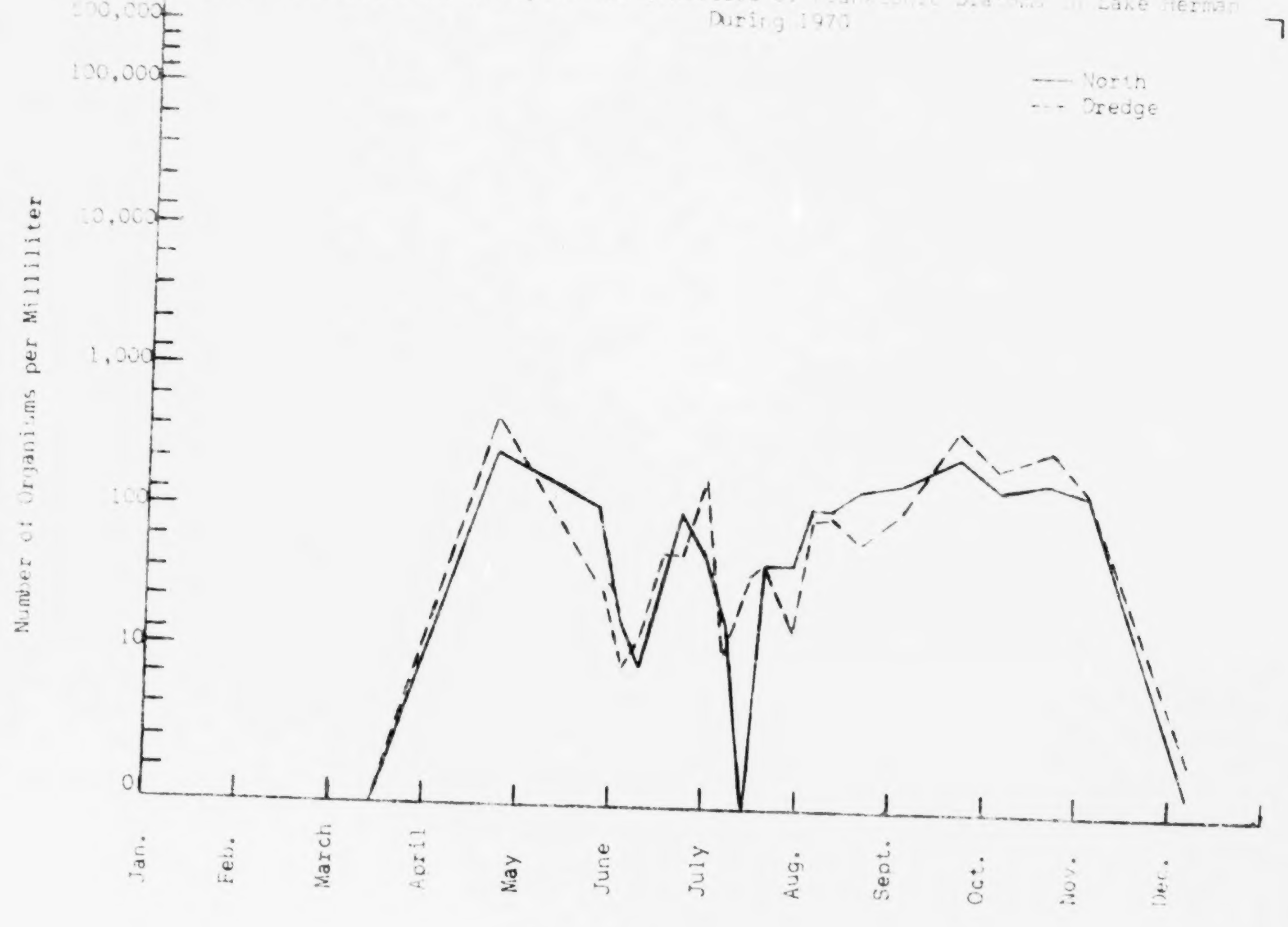


Figure 60. Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1970

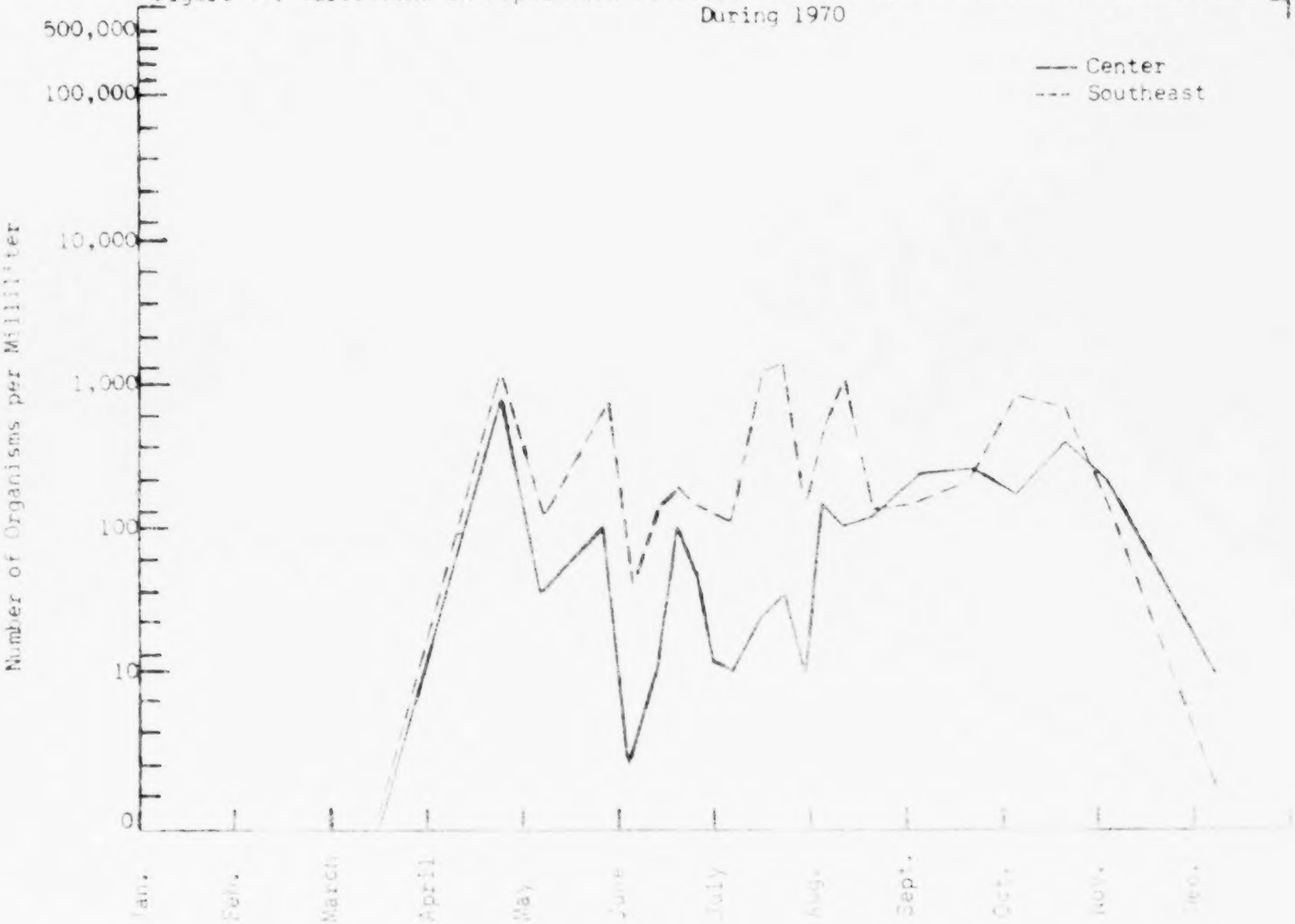


Figure 61. Variations in Population Densities of Planktonic Diatoms in Lake Herman
During 1971

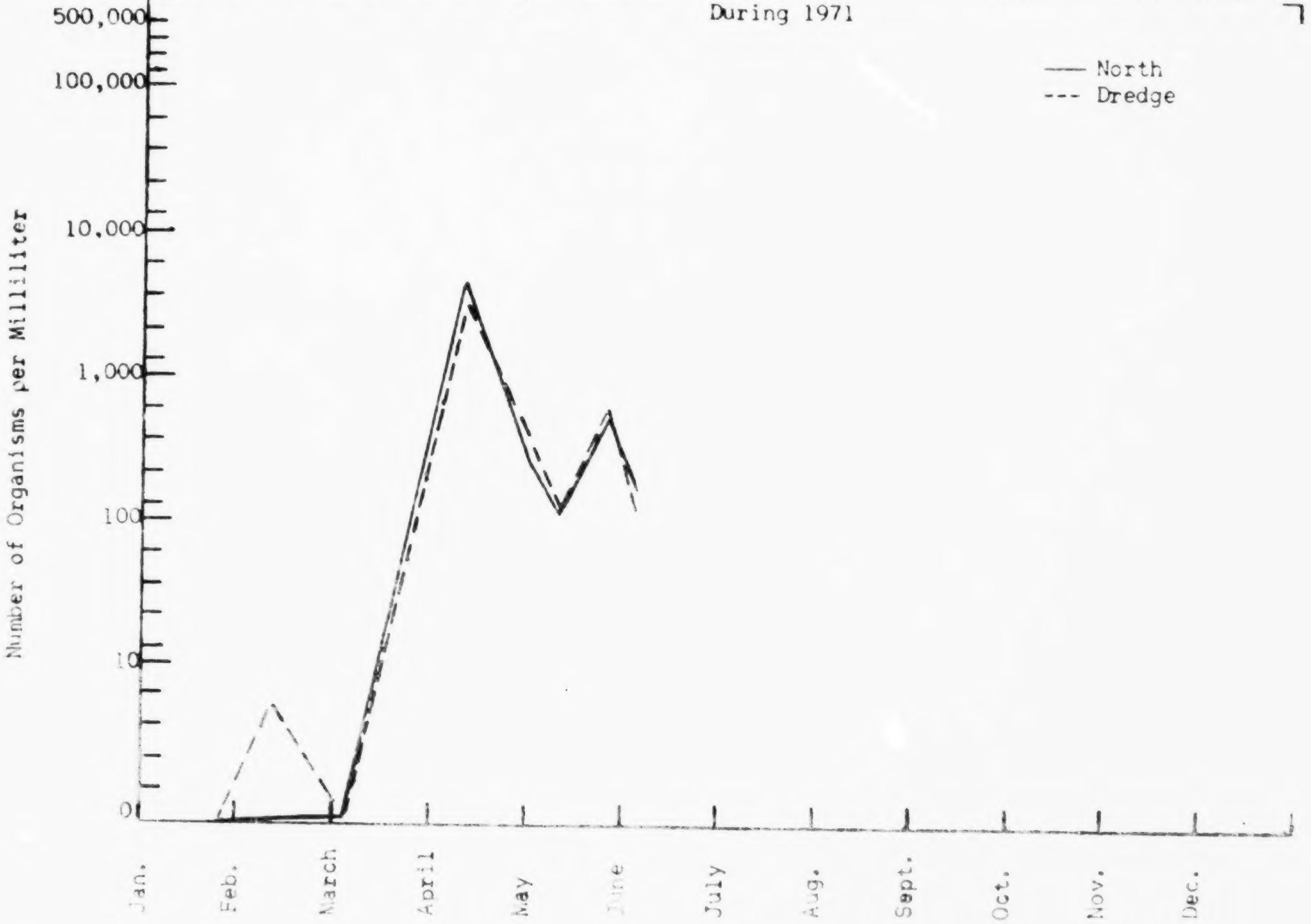
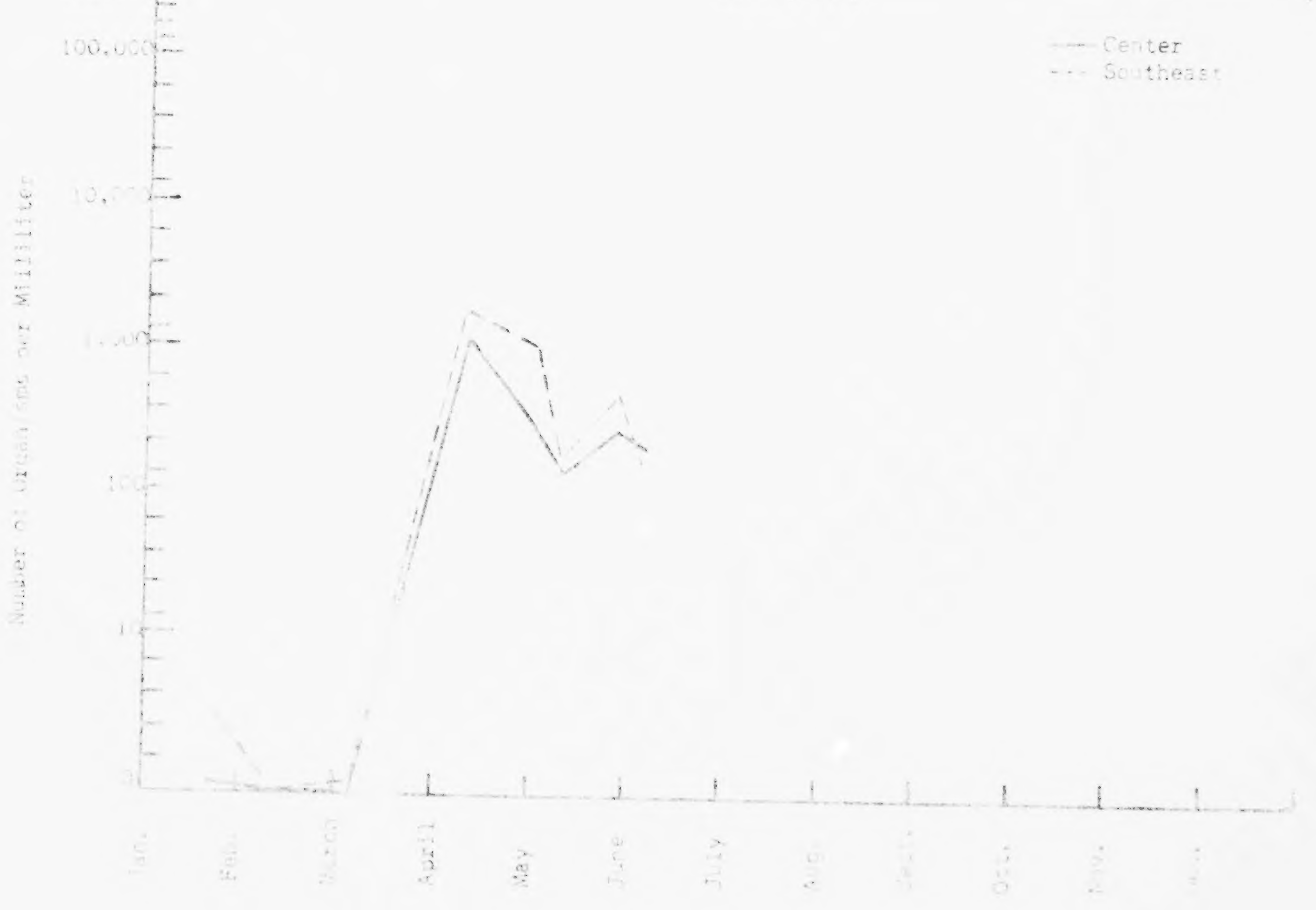
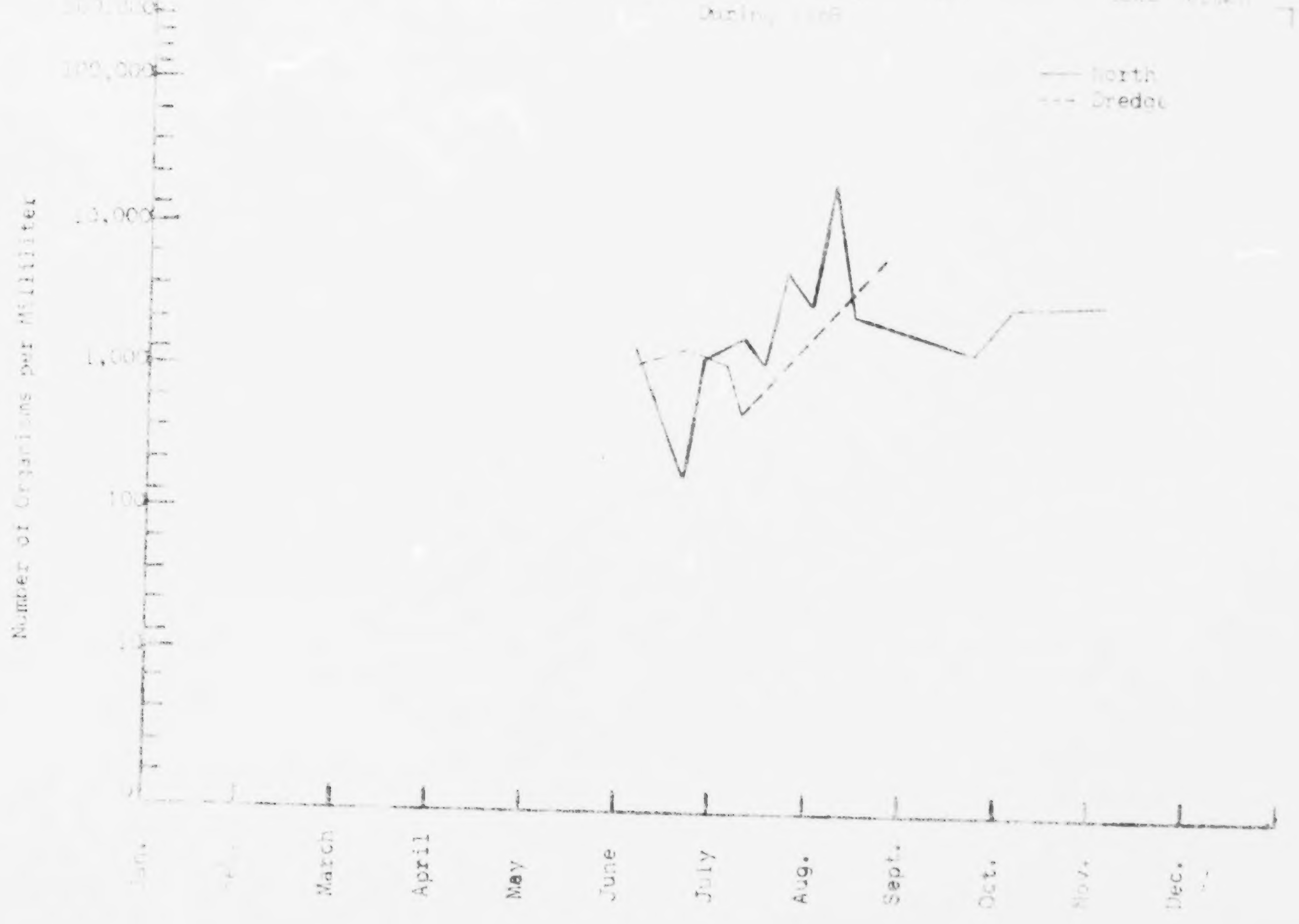


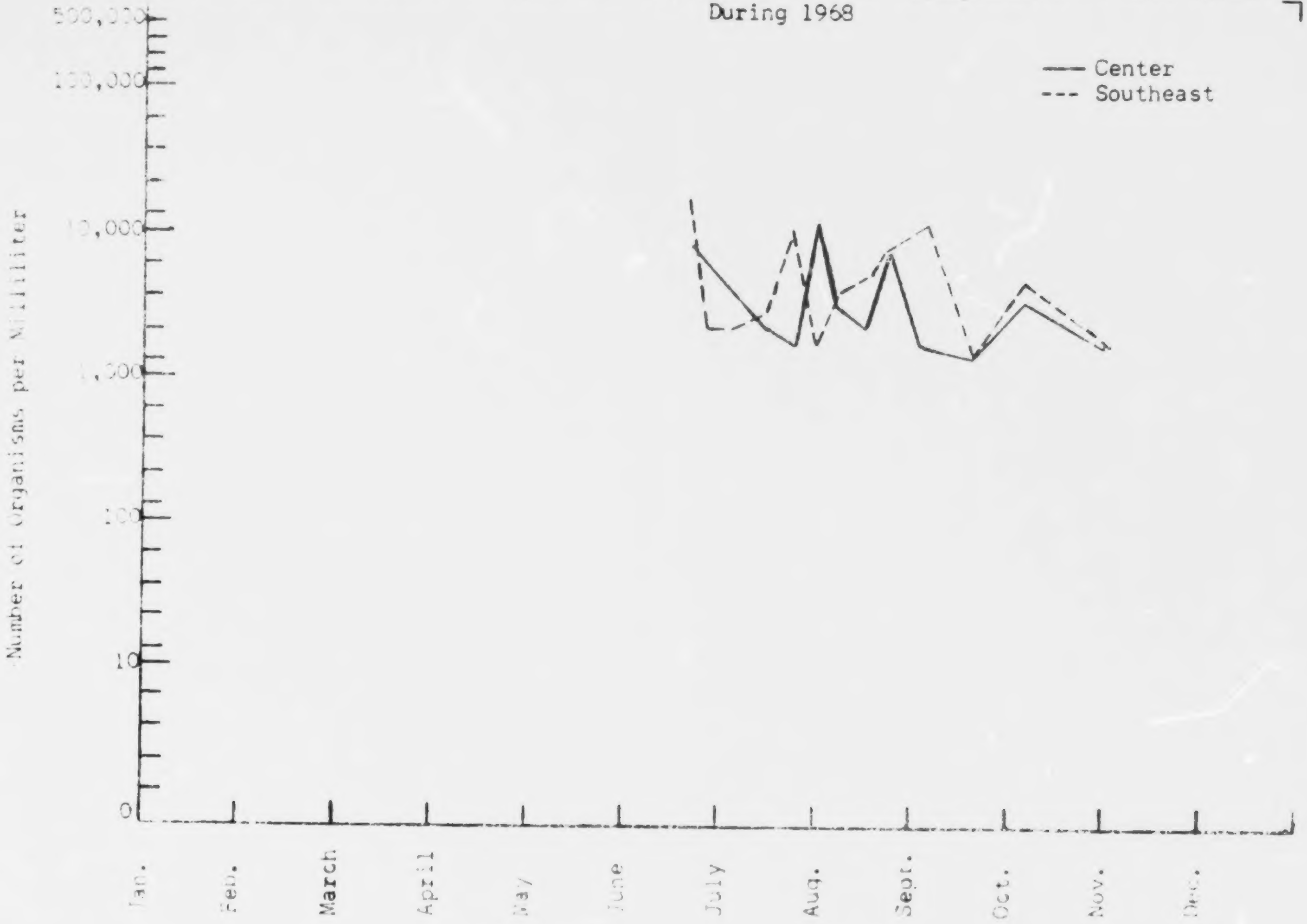
Figure 42. Variations in Population Densities of Planktonic Diatoms in Lake Herman During 1971





re 67. [illegible] Population Densities [illegible] Lake [illegible] During 1968

Figure 54. Variations in Population Densities of Total Phytoplankton in Lake Herman During 1968



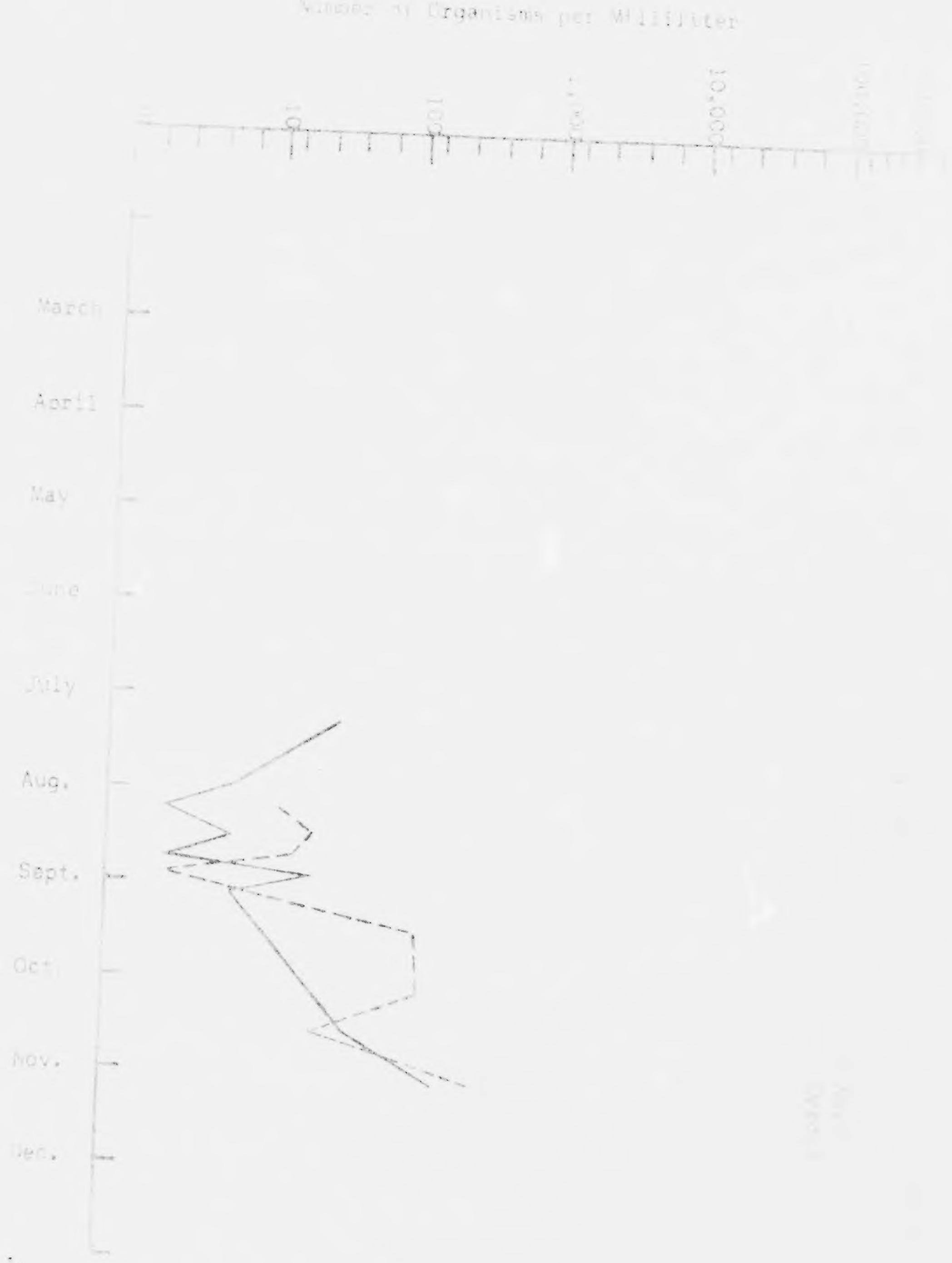

Number of Organisms per Milliliter
10
100
1,000
10,000
100,000
March
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

Figure 56. Variations in Population Densities of Total Phytoplankton in Lake Herman During 1969

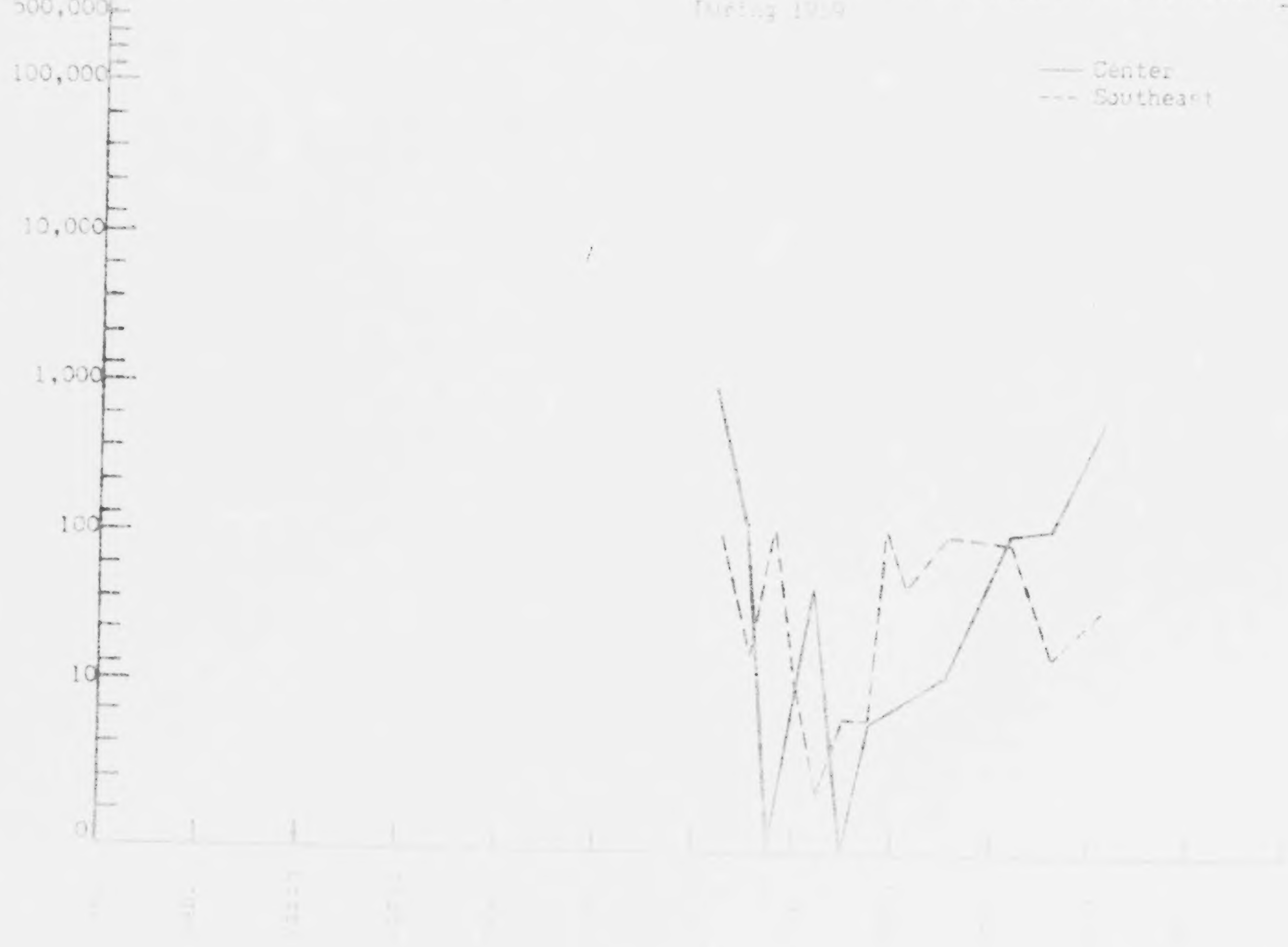


Figure 67. Variations in Population Densities of Total Phytoplankton in Lake Herman During 1970

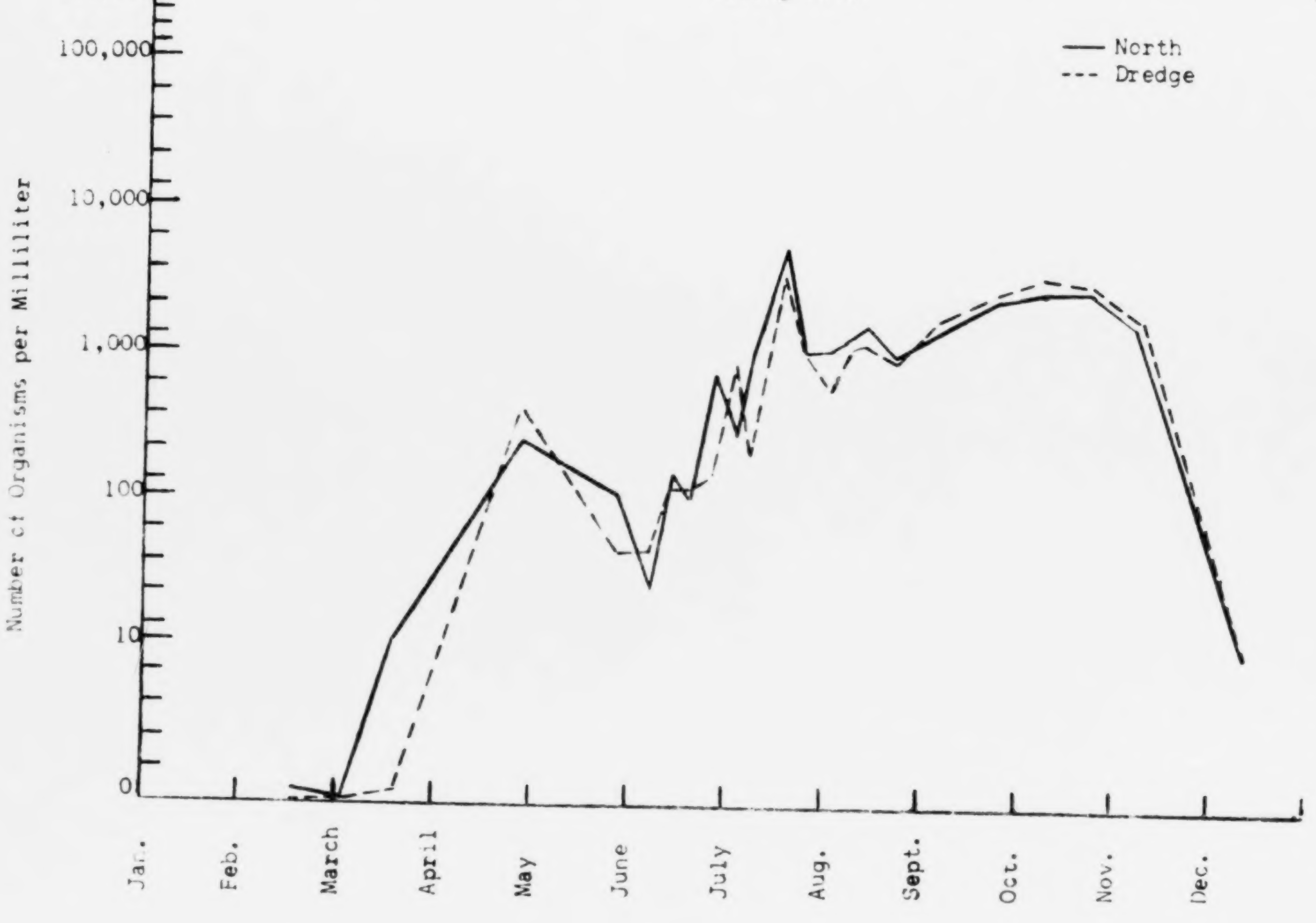


Figure 6B. Variations in Population Densities of Total Phytoplankton in Lake Herman During 1970

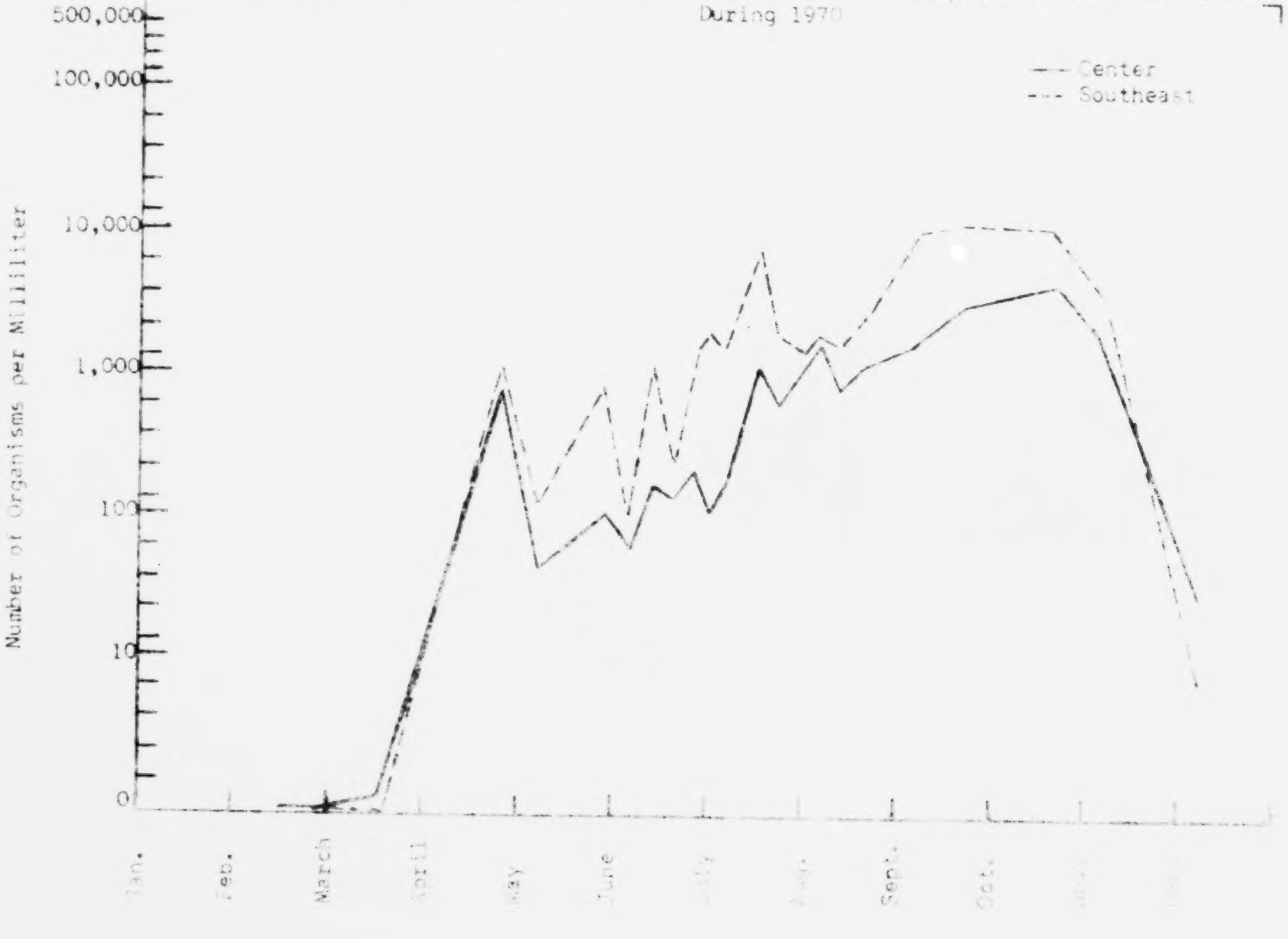
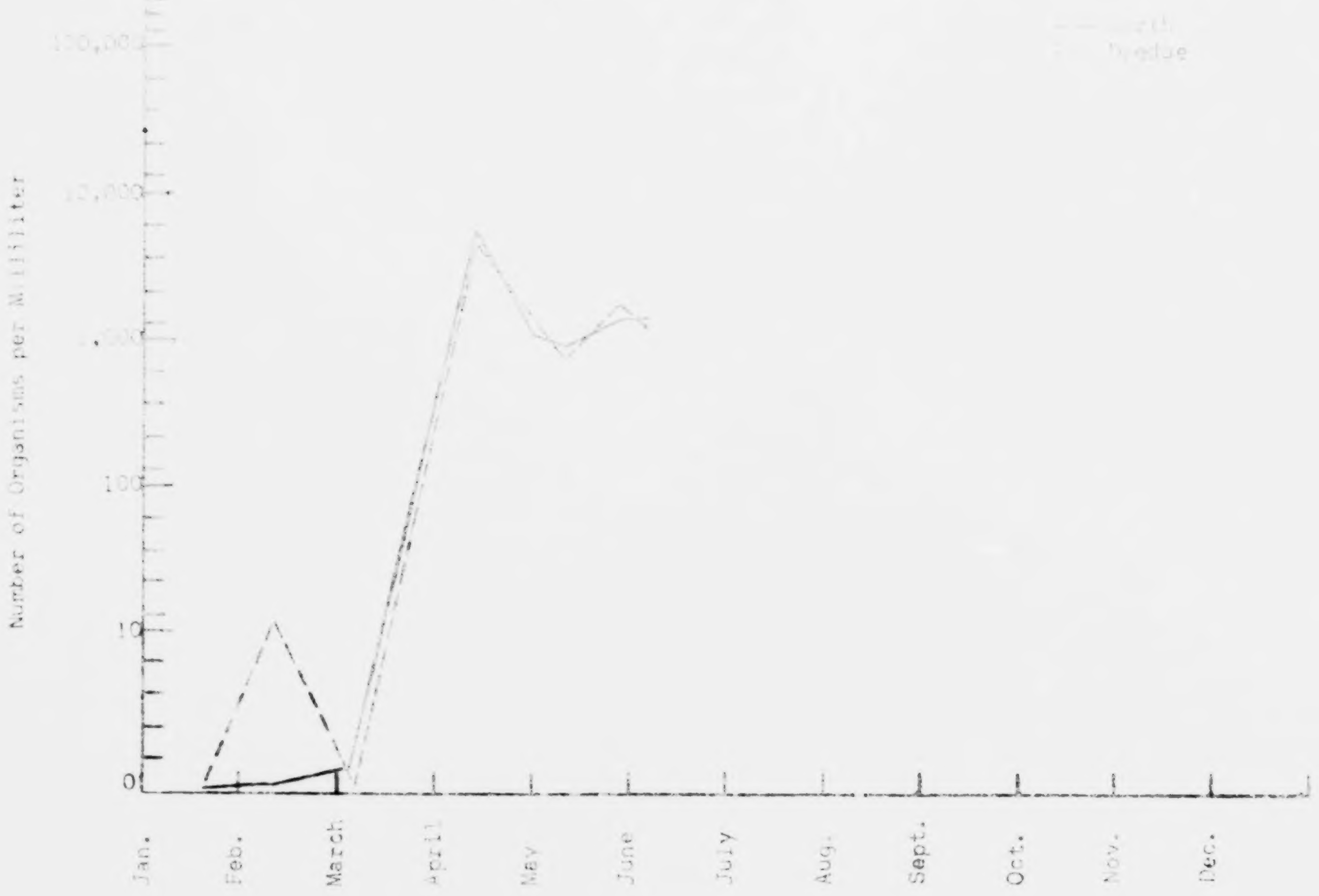


Figure 19. Variations in Population Densities of Total Phytoplankton in Lake Herman During 1971



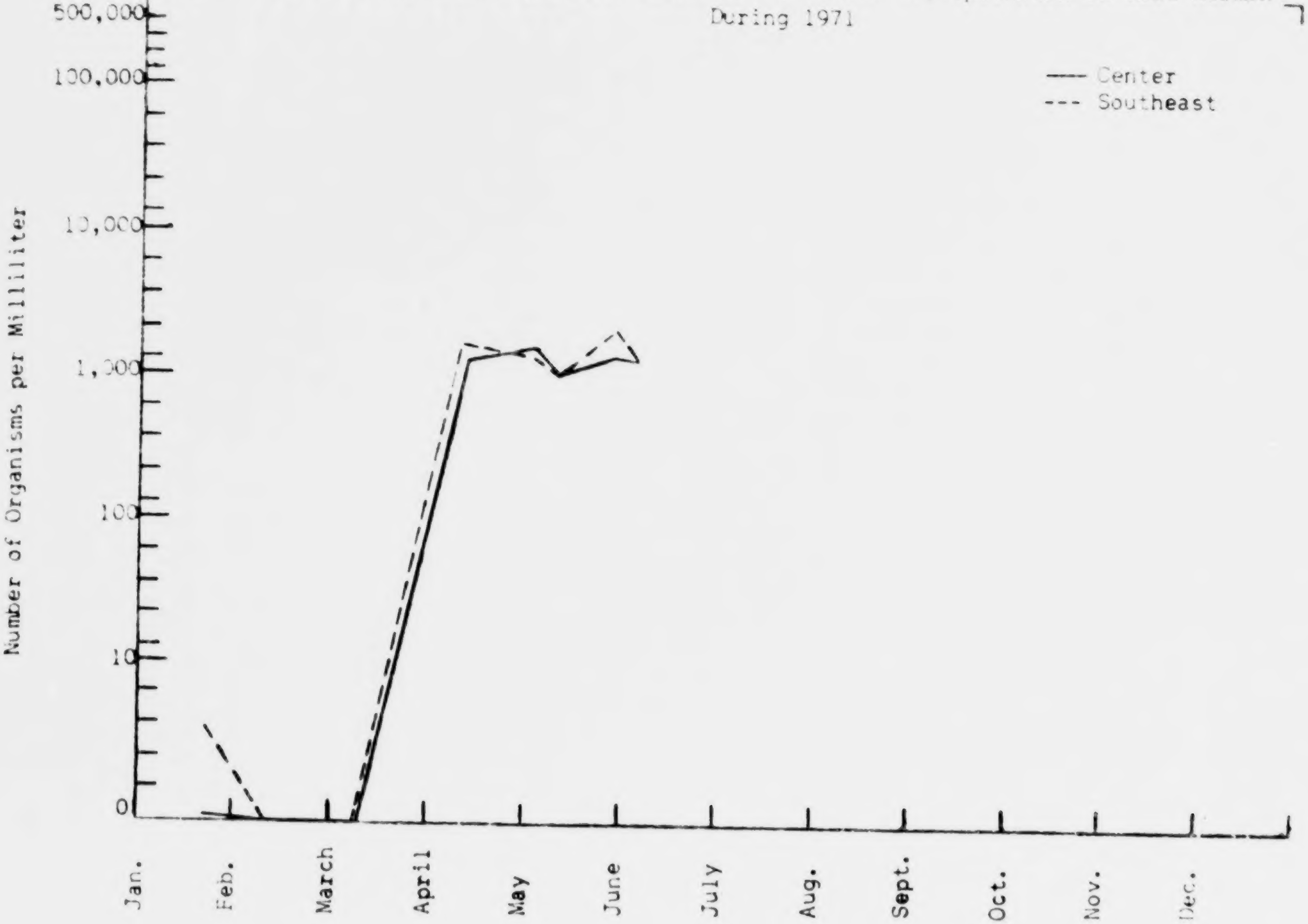


Figure 70. Variations in Population Densities of Total Phytoplankton in Lake Herman During 1971

Species of Surirella were almost entirely responsible for the diatom populations in 1969. The data for that year indicate very low population densities of these species.

Species of Cyclotella and Surirella were equally abundant in the spring bloom of 1970. The summer bloom was composed primarily of species of Cyclotella, Melosira, and Nitzschia. The fall bloom included all those responsible for the earlier two blooms plus Stephanodiscus sp.

Species of Cyclotella composed most of the early bloom in 1971. Although the species mentioned above were more abundant during years of low diatom densities, during years of high population densities species of Cyclotella were the most abundant. Other diatoms which were present include species of Cymatopleura, Fragilaria, Gomphonema, Navicula, Pinnularia, and Synedra.

## Relationship of Blue-Greens and Diatoms in Lake Herman

The inverse relationship between diatoms and blue-greens in Lake Madison was not found in Lake Herman. The greatest densities of diatoms and blue-greens during this study occurred in 1968. Diatom blooms during 1968 alternated only slightly with blue-green blooms.

Diatom populations and blue-green populations in 1969 were extremely low as compared with the rest of the project period; thus, the two groups may not have affected each other at such low densities.

The blue-green densities in 1970 were fairly high, although not nearly as high as the densities of 1968. Data from that year indicate relatively low population densities of diatoms.

When the project terminated in June of 1971, data to that point indicated alternating blooms between the diatoms and blue-greens for that year. The April diatom count was 7,000 organisms/ml while the blue-greens were about 700 organisms/ml. By late May the blue-greens had increased to 3,400 organisms/ml and the diatoms had decreased to 700 organisms/ml.

## Comparison of Phytoplankton Between Lake Madison and Lake Herman

During the entire three-year project, which began in June, 1968, and terminated in June, 1971, Lake Madison was more productive in terms of total phytoplankton.

The greatest density of phytoplankton in Lake Madison in 1968 was approximately 40,000 organisms/ml. Although the phytoplankton densities did not remain that high for any great length of time, they were consistently higher in Lake Madison than in Lake Herman.

The phytoplankton densities during 1969 were the lowest of the three-year project. The greatest density in Lake Herman during 1969 was only 1,200 organisms/ml, and it was usually much lower. Lake Madison was much lower in total phytoplankton during 1969 than during any other year. Although the greatest density was only 18,000 organisms/ml, that was still much higher than the greatest density in Lake Herman. The phytoplankton density in Lake Madison remained high until an ice cover formed, while the phytoplankton density in Lake Herman dropped sharply prior to the formation of an ice cover.

The phytoplankton densities in Lake Madison and Lake Herman were about the same during 1970. However, the seasonal composition of the phytoplankton was quite different. The phytoplankton density in Lake Madison was the highest in the middle of the summer (57,000 organisms/ml) and was made up almost entirely of diatoms. The phytoplankton then decreased rapidly and was quite low (1,000 organisms/ml) by October. The phytoplankton population in Lake Herman was composed primarily of blue-greens, which were less abundant than in Lake Madison, and remained relatively high (6,000 organisms/ml) until an ice cover formed.

An early bloom developed in both lakes during April of 1971. The bloom in Lake Madison was considerably denser than the bloom in Lake Herman (27,000 and 8,000 organisms/ml, respectively). The blooms in both lakes were composed primarily of diatoms. The early bloom of diatoms in Lake Madison had practically disappeared by late May, and the blue-greens had not begun to increase at that time; therefore, the phytoplankton density was a very low 20 organisms/ml. The diatom density in Lake Herman was quite low by late May but the blue-greens had begun to increase; the phytoplankton density was about 4,000 organisms/ml. Although no further densities were recorded for this project, the results from another project indicate heavy blue-green blooms in both lakes throughout the summer and fall of 1971.

Although the greens and euglenoids did not compose a significant portion of the phytoplankton in Lake Madison, their early blooms undoubtedly influenced the ensuing phytoplankton. Lake Herman did not have blooms of green algae or euglenoids.

### Copepod and Cladoceran Populations in Lake Madison and Lake Herman From May, 1970 to June, 1971.

An analysis of copepod and cladoceran populations was begun in May of 1970; thus, they were studied for only a one-year period. The copepod populations of both lakes were composed of *Osphranticum labronectum* and *Ectocyclops phaleratus*. The cladoceran populations in both lakes were composed primarily of species of *Daphnia*, but *Bosmina coregoni* was occasionally collected.

The copepod population in Lake Madison was usually greater than the cladoceran population (Figures 71 to 76). The cladoceran population in

March
May
June
July
Sept
Oct

Figure 72. Variations in Population Densities of Cladocerans in Lake Madison During 1970

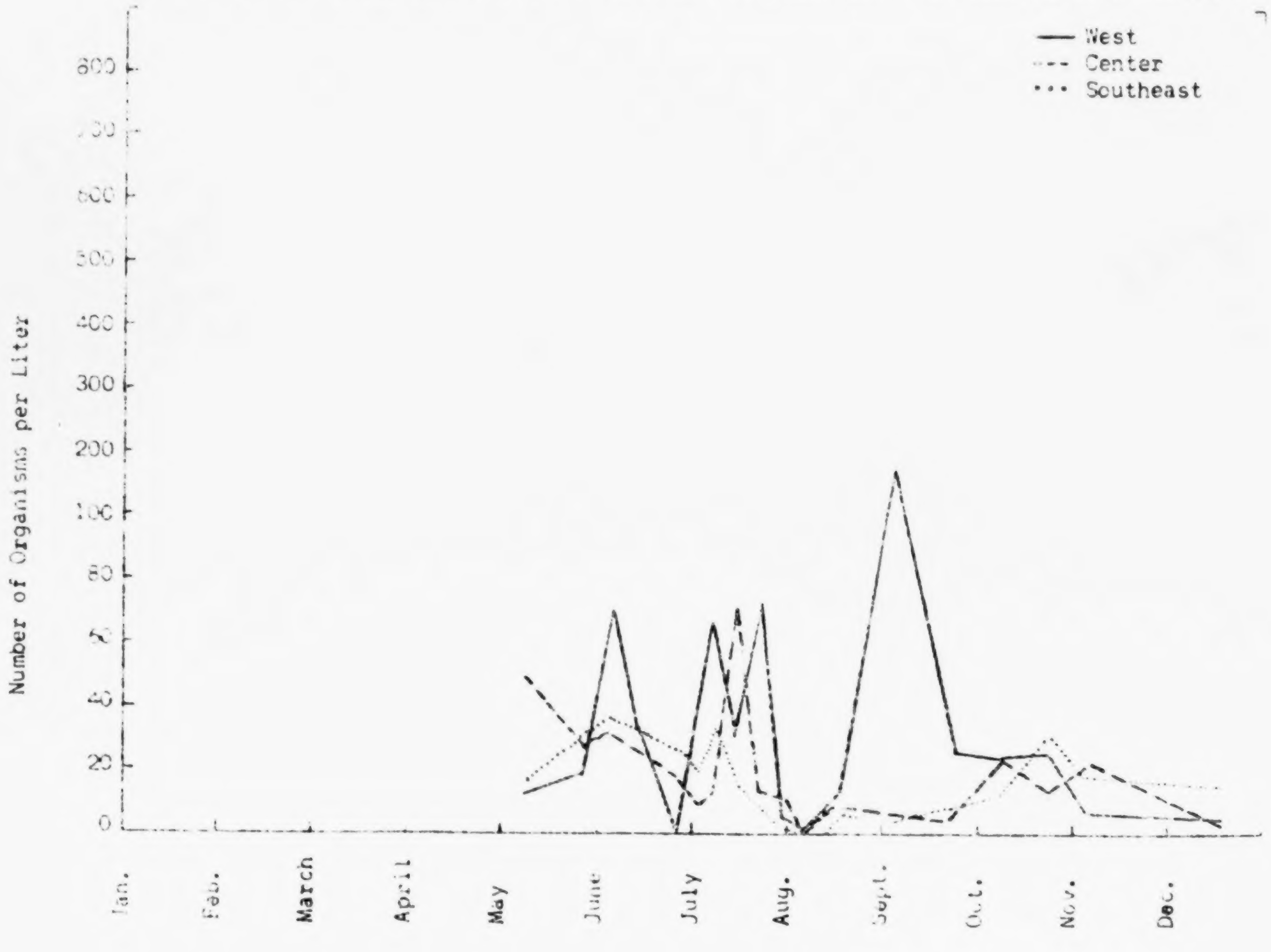


Figure 73. Variations in Average (Three Sites) Population Densities of Copepods and Cladocerans in Lake Madison During 1970

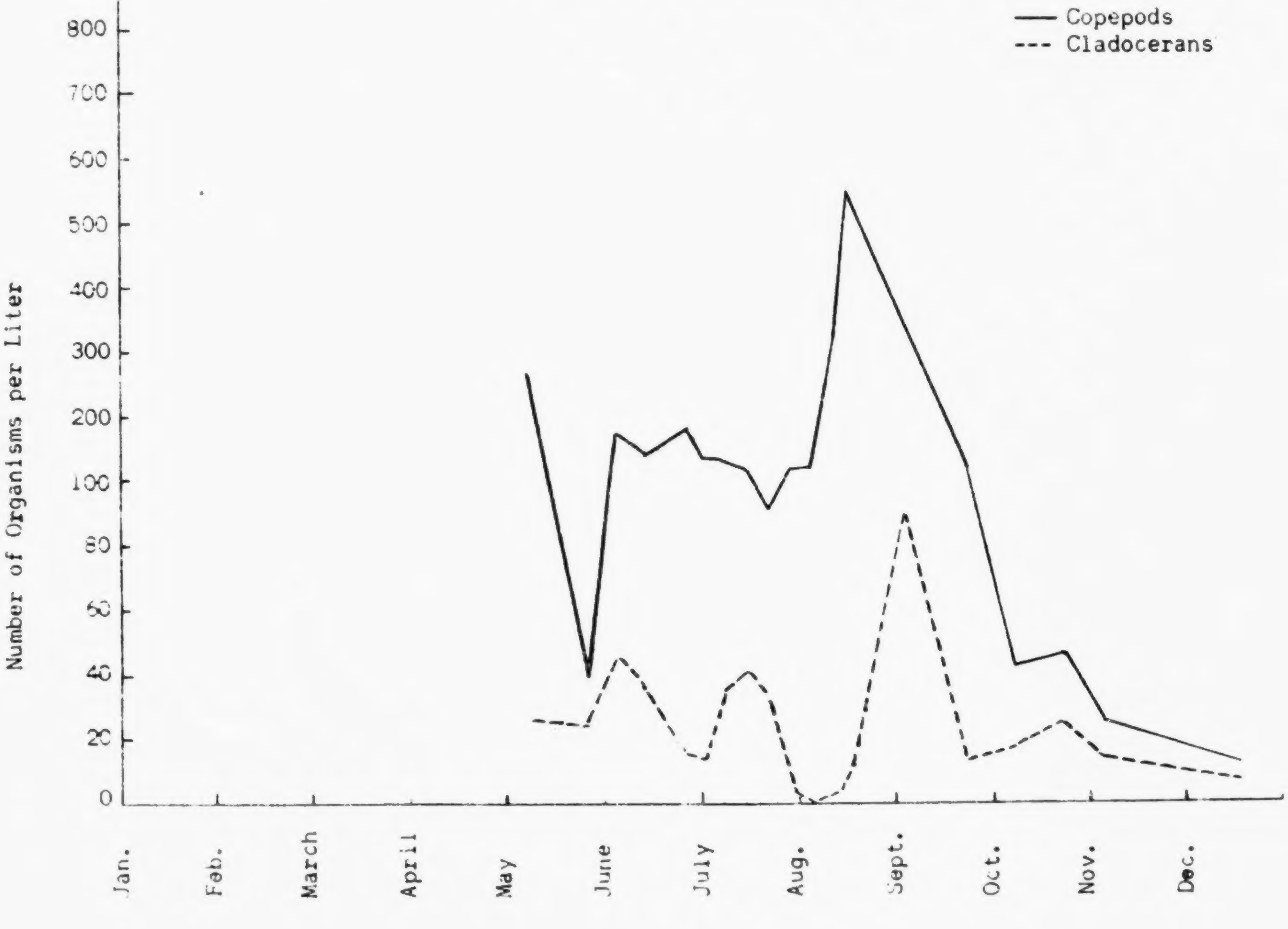


Figure 74. Variations in Population Densities of Copepods in Lake Madison During 1971

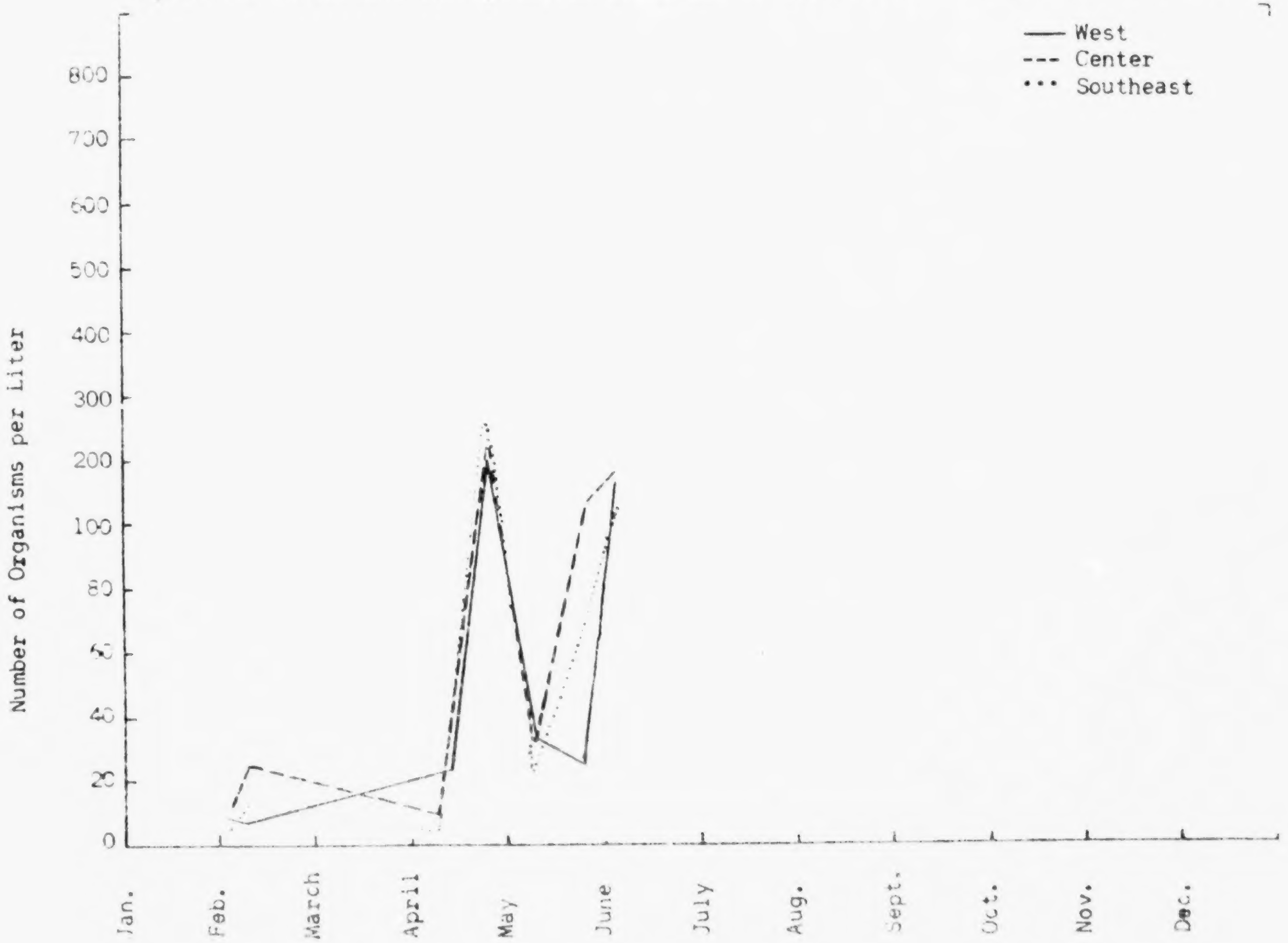


Figure 75. Variations in Population Densities of Cladocerans in Lake Madison During 1971

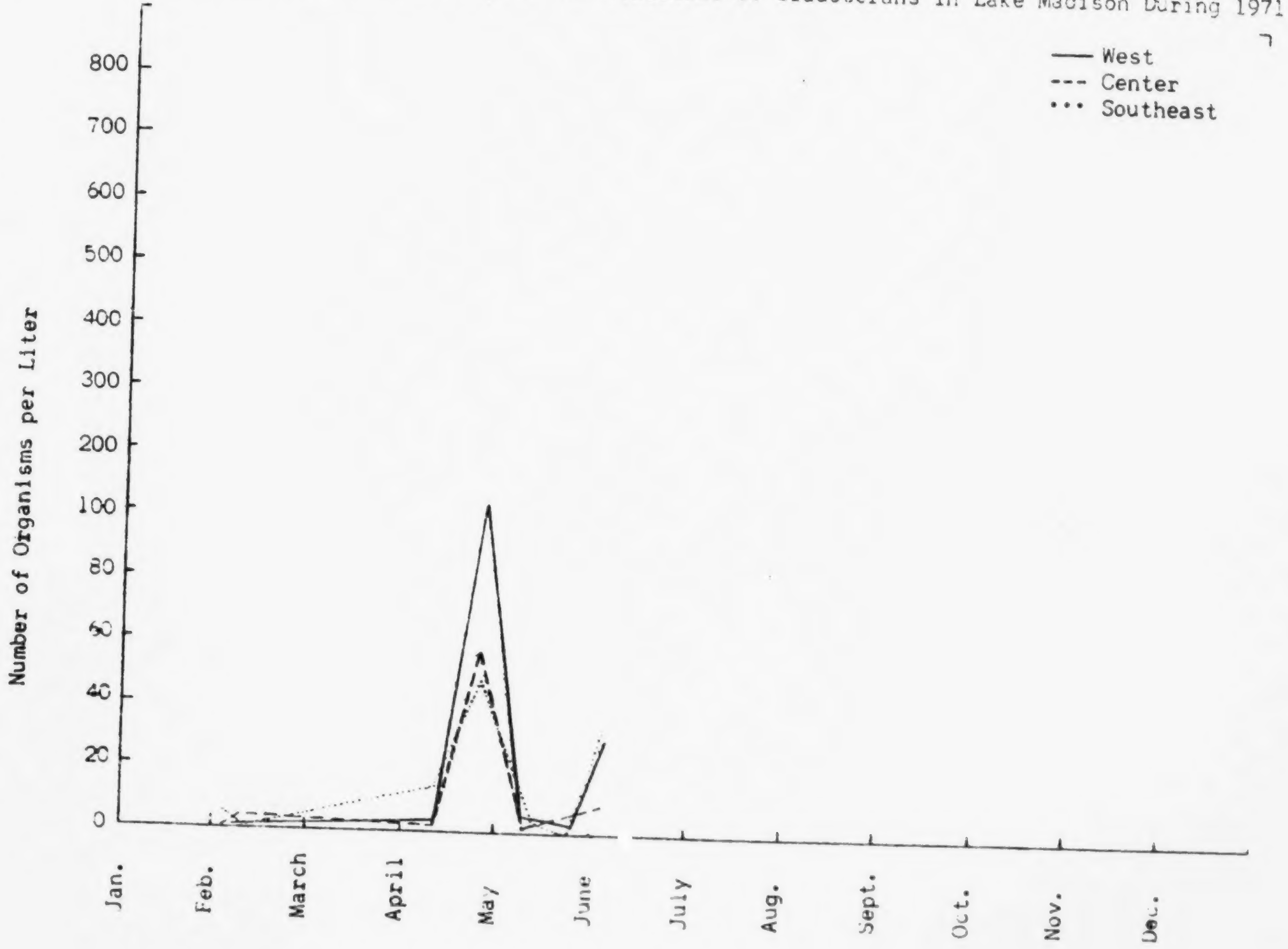
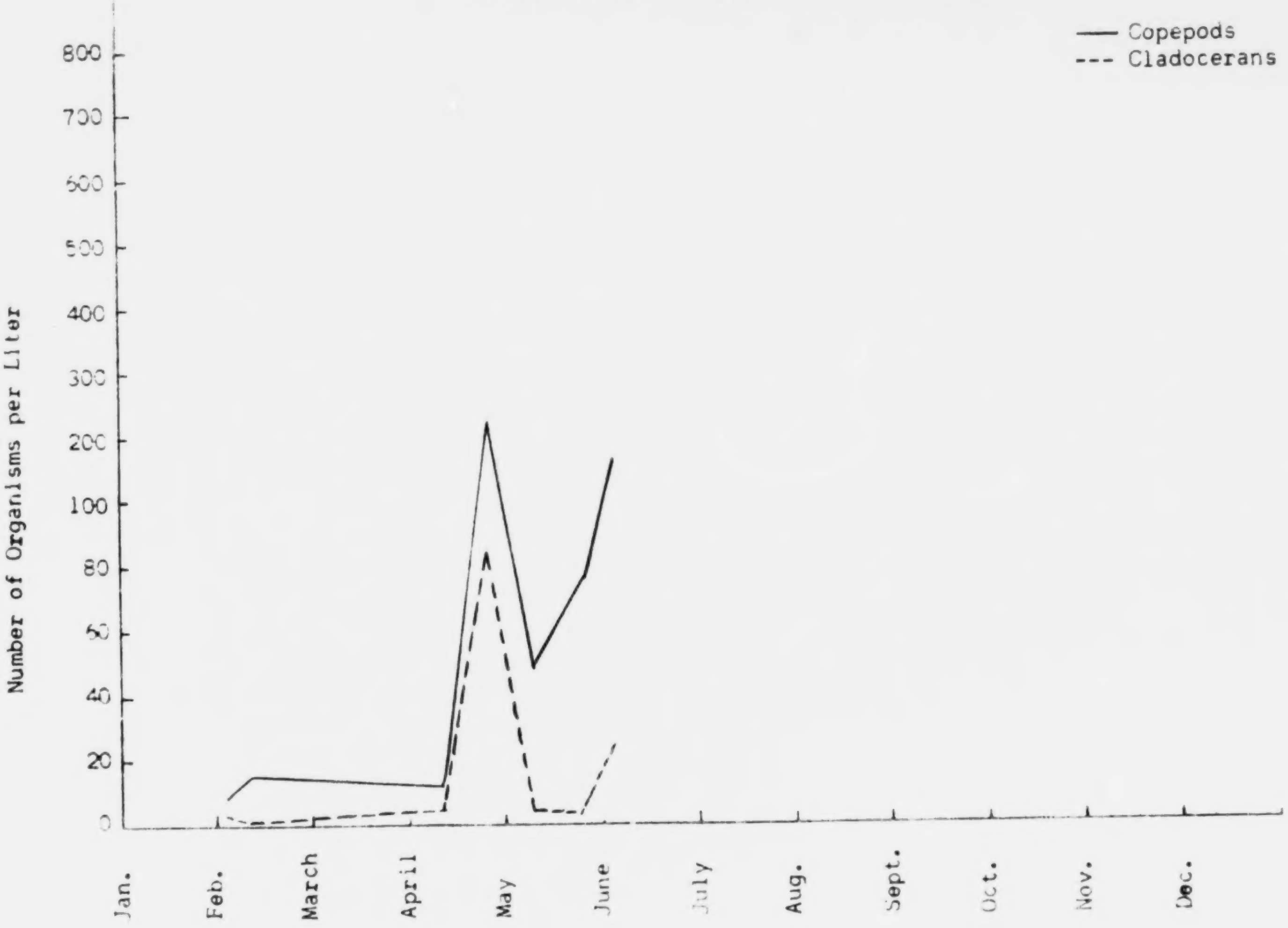


Figure 76. Variations in Average (Three Sites) Population Densities of Copepods and Cladocerans in Lake Madison During 1971



Lake Herman was usually greater than the copepod population except between early May and mid-July (Figures 77 to 86).

The cladoceran population of Lake Herman peaked much earlier and much higher in 1970 (Figures 73 and 81) than did the cladoceran population of Lake Madison. The greatest density in Lake Herman occurred in late April and early May and was 250 organisms/l. A second peak (180 cladocerans/l) occurred in early July. By mid-July, however, the cladoceran population had decreased nearly to zero and it remained very low during the remainder of the year. The greatest density in Lake Madison wasn't reached until September, and it was only about 80 organisms/l (unless a peak had occurred in April prior to the beginning of the counts). Although there was a sharp decrease in cladocerans after September, the density remained near 20 organisms/l (Figure 86). The cladoceran population in Lake Herman during 1971 did not begin to increase until mid-May and was above 100/l by early June (Figure 76). A peak had not been reached when the project was terminated in early June.

The copepod populations reached greater densities in Lake Madison (600 organisms/l) than in Lake Herman (250 organisms/l); however, the populations in Lake Madison decreased much earlier than in Lake Herman. The copepod populations in Lake Madison decreased to 40 organisms/l during October and to less than 20 organisms/l during December. A population of over 100 organisms/l was present in Lake Herman throughout the fall of 1970 and into February of 1971, when it started to decrease. Early in 1971, the population of copepods was higher in Lake Herman than in Lake Madison.

The chemical and biological parameters of Lake Madison (a sewage polluted lake) and Lake Herman (a silt polluted lake) clearly follow the same seasonal trends. The sharp rise in some nutrients and fall in other nutrients at the time of the spring runoff, the summer fluctuations of certain nutrients with biological growth, the seasonal bloom of diatoms and blue-green alga as well as the inverse relationship between these two types of blooms all follow the same pattern in both lakes. It is of particular interest that both lakes have very high levels of phosphorus. Herein is one instance where agriculture and silt have released as much phosphorus, if not more, into surface waters as domestic sewage effluent with its phosphate load from detergents. Both lakes appeared to have an abundance of phosphorus even at the height of the algal blooms but the nitrate level in both lakes decreased to near zero during these blooms.

It is interesting to note that both lakes even responded to a fish kill in the same manner. Lake Herman experienced a complete fish kill during the 1968-1969 winter. During the summer of 1969 Lake Herman showed a marked decrease in the density of phytoplankton growth despite the fact that there were no significant differences in phosphorus and nitrogen

Figure 77. Variations in Population Densities of Copepods in Lake Herman During 1970

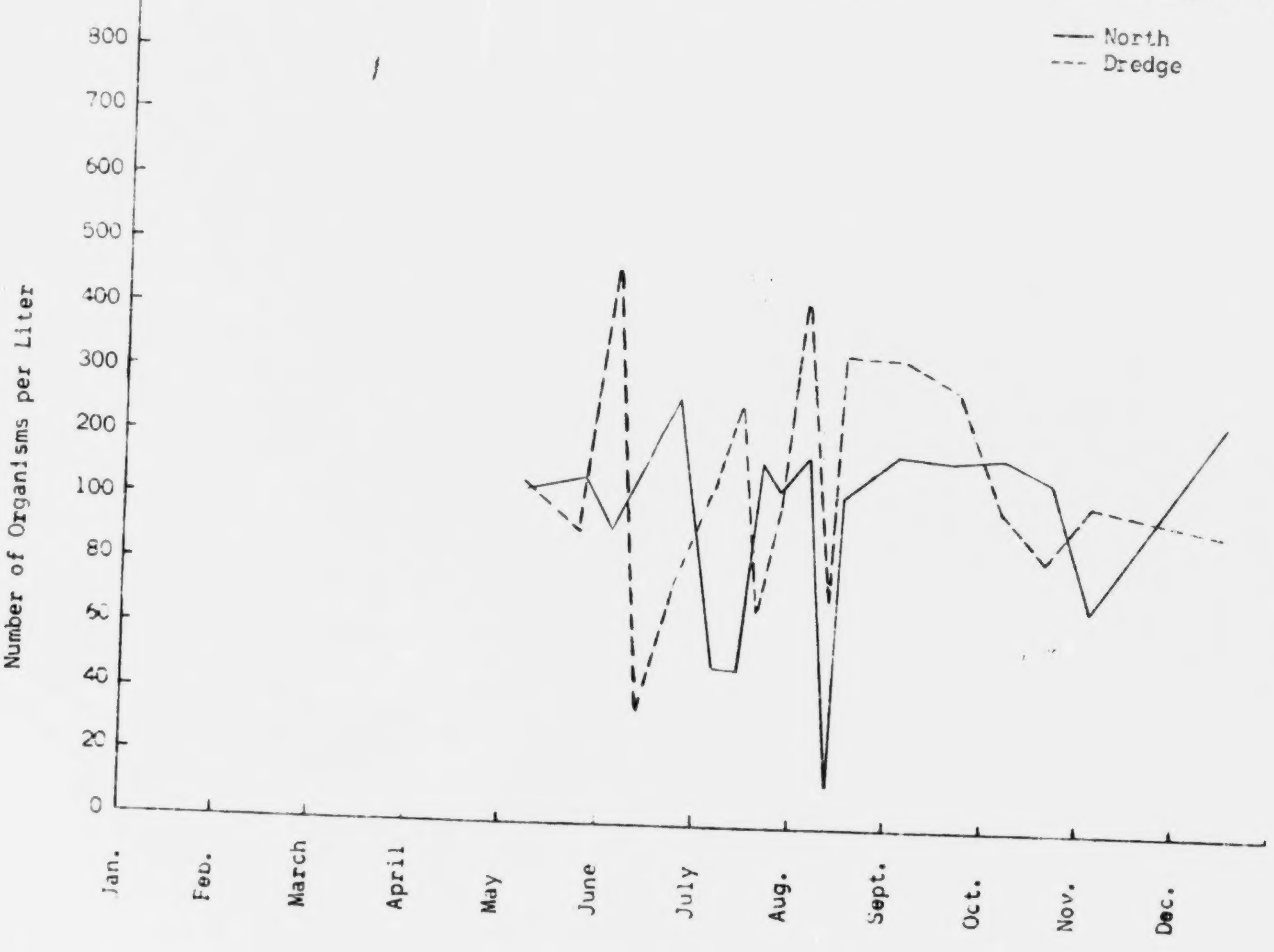


Figure 78. Variations in Population Densities of Copepods in Lake Herman During 1970

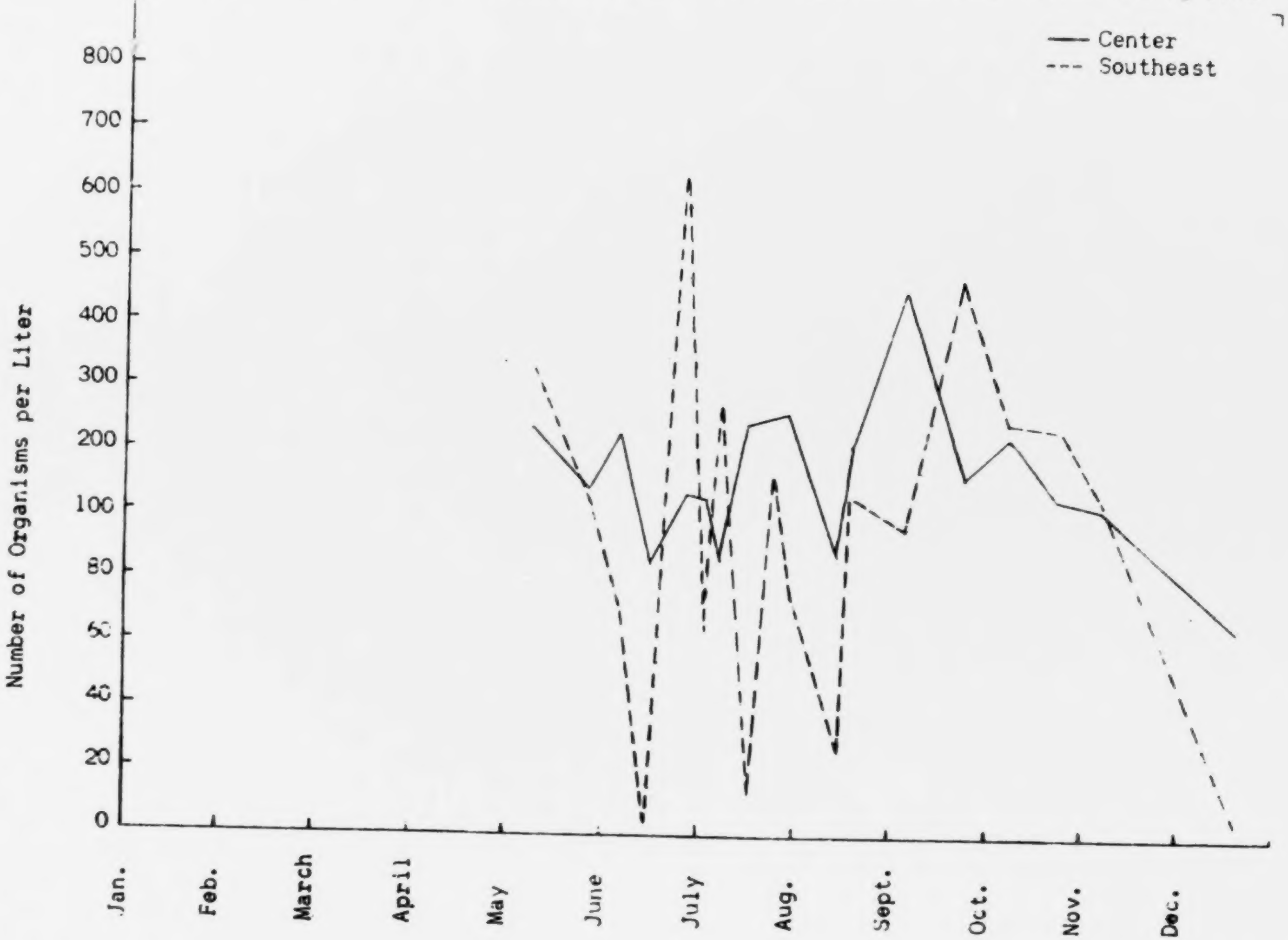


Figure 79. Variation in Population Densities of Cladocerans in Lake Herman During 1970

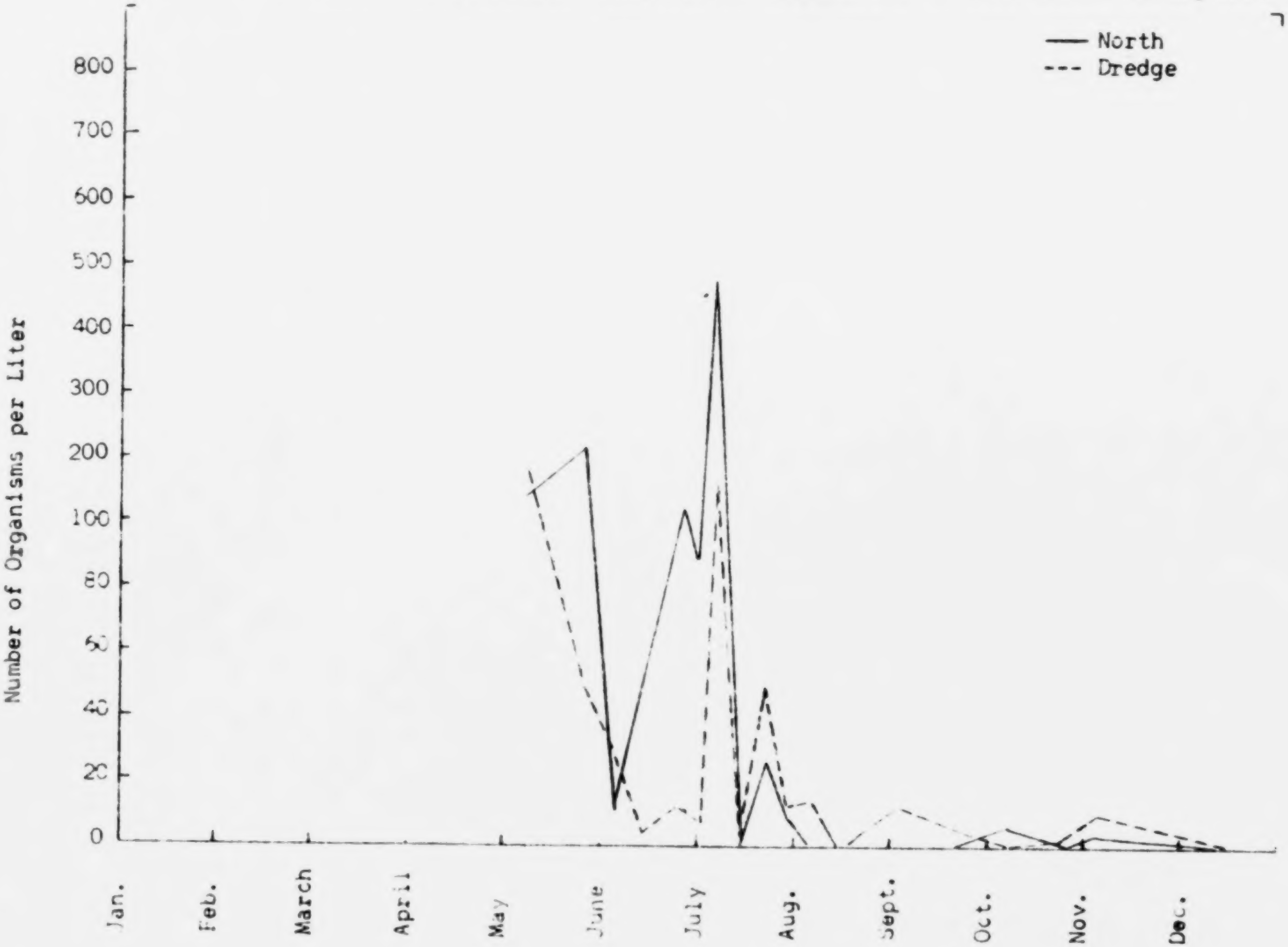


Figure 80. Variations in Population Densities of Cladocerans in Lake Herman During 1970

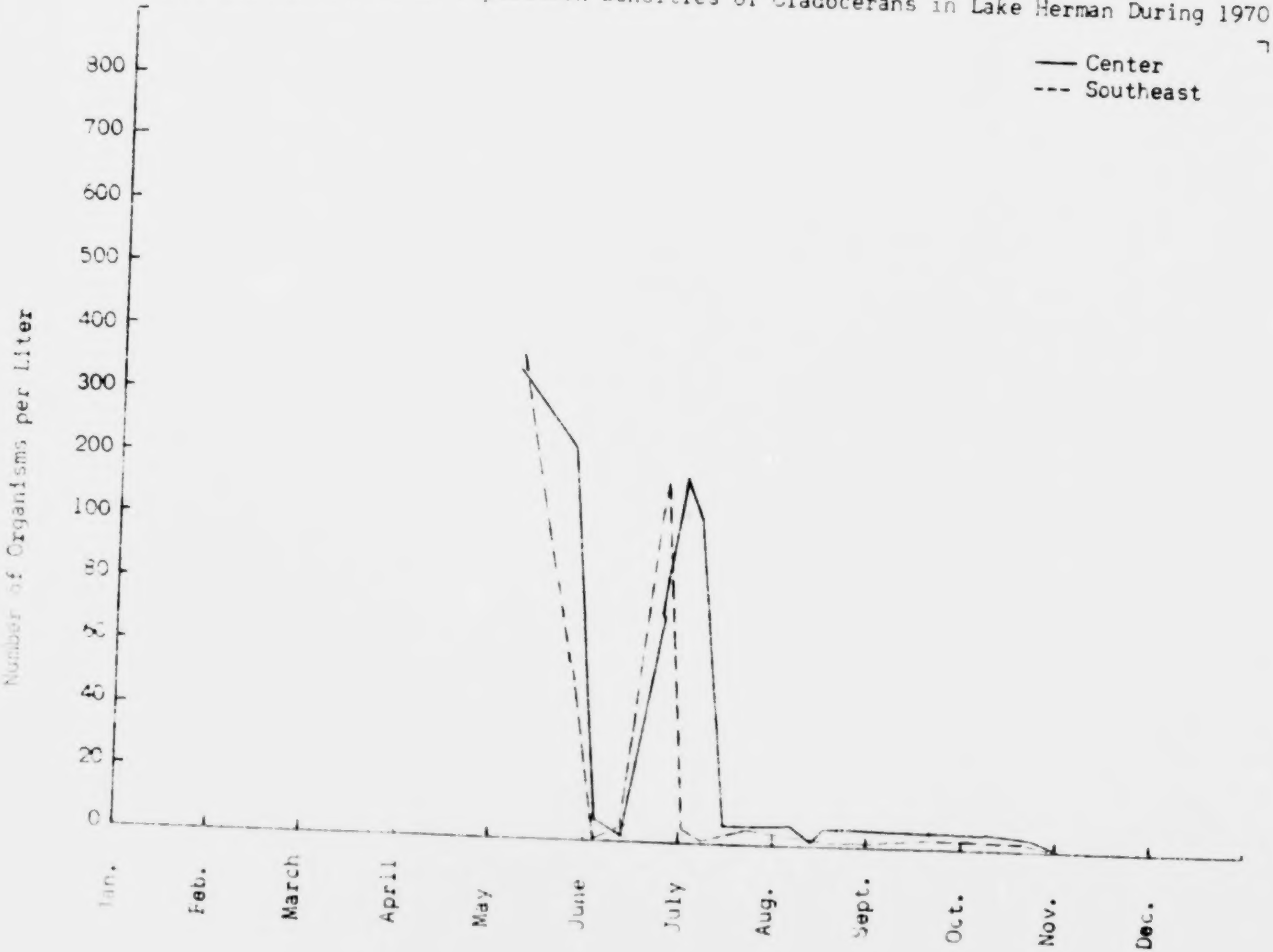


Figure 81. Variations in Average (Four Sites) Population Densities of Copepods and Cladocerans in Lake Herman During 1970

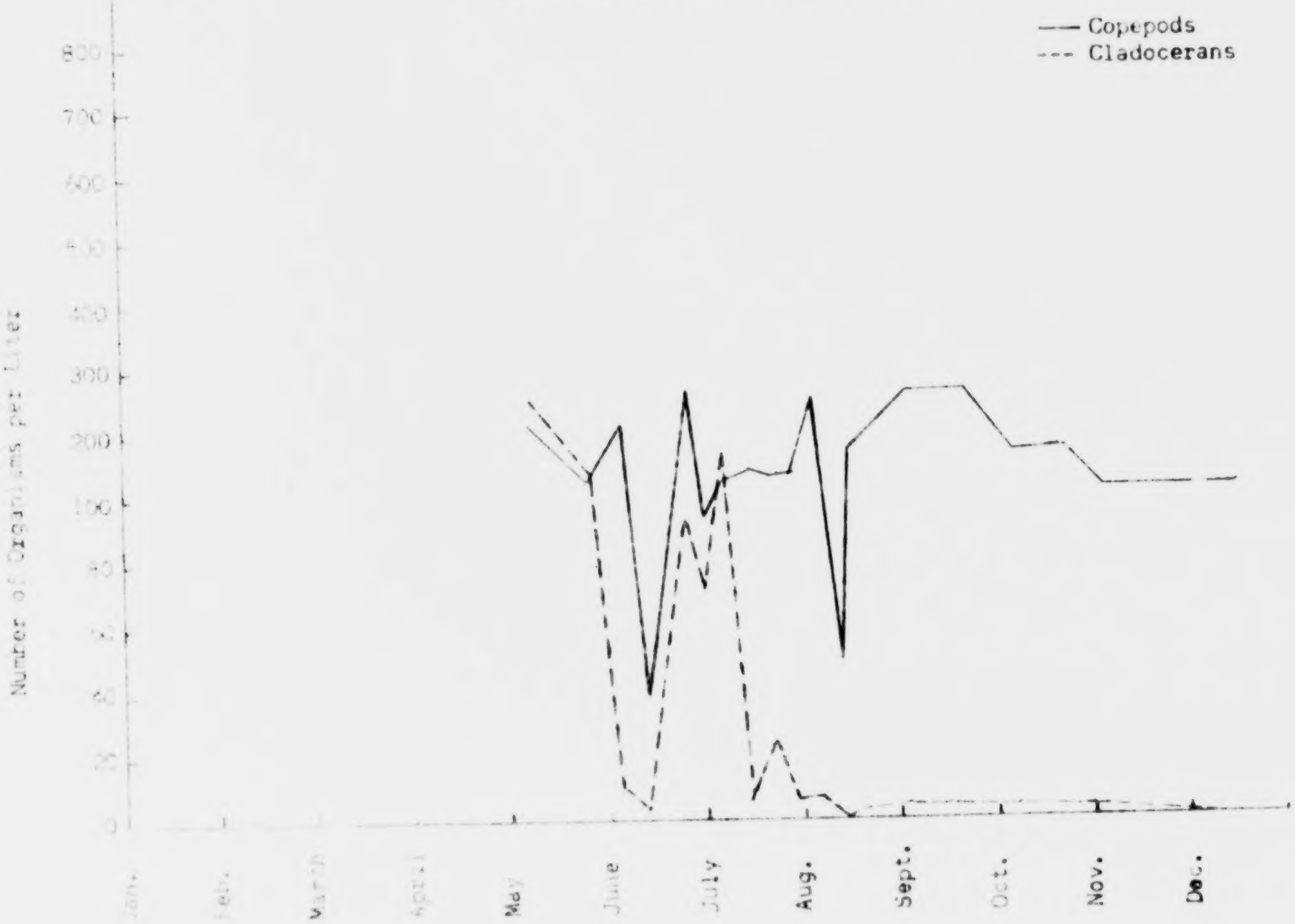


Figure 82. Variations in Population Densities of Copepods in Lake Herman During 1971

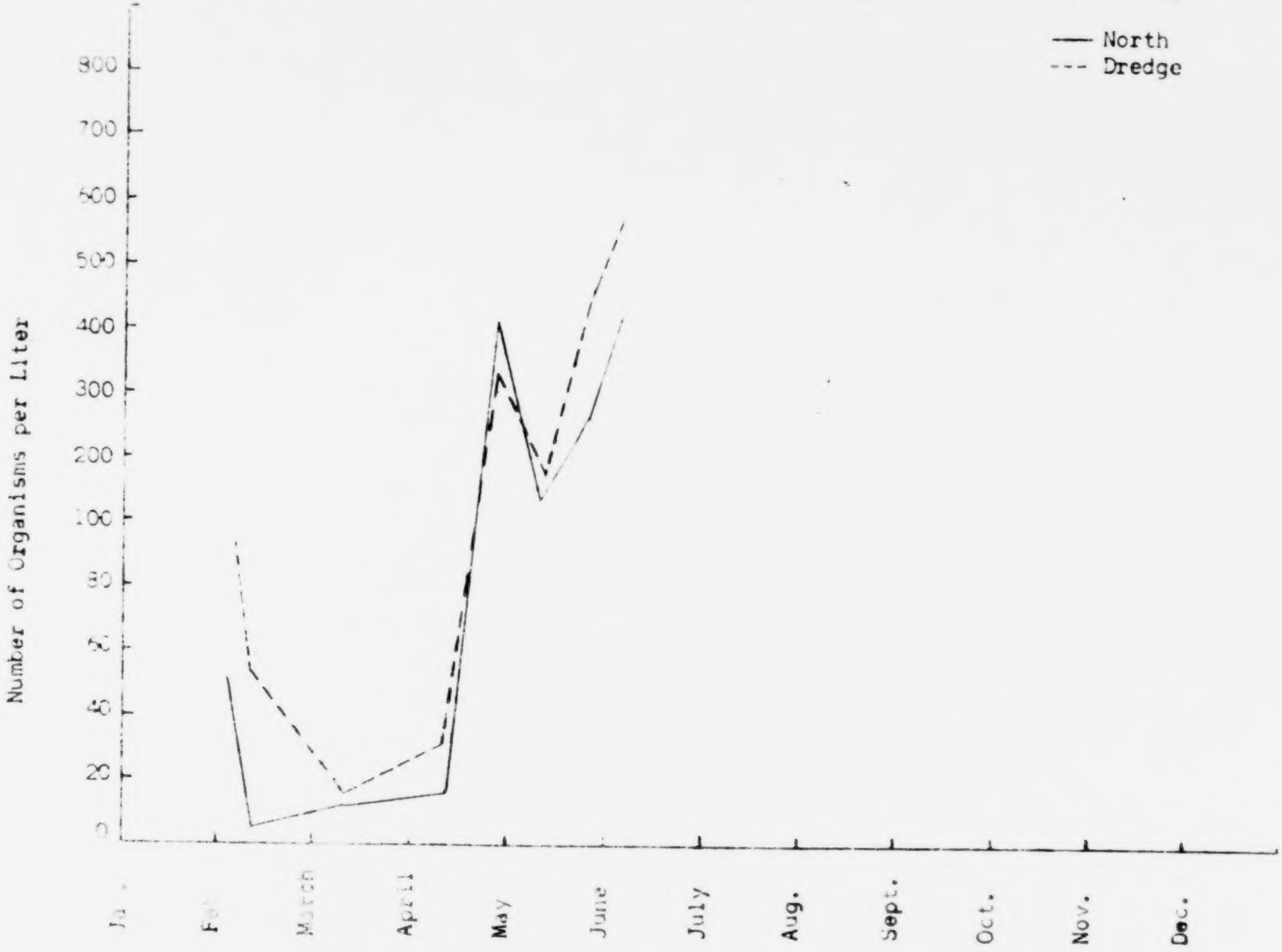


Figure 83. Variations in Population Densities of Copepods in Lake Herman During 1971

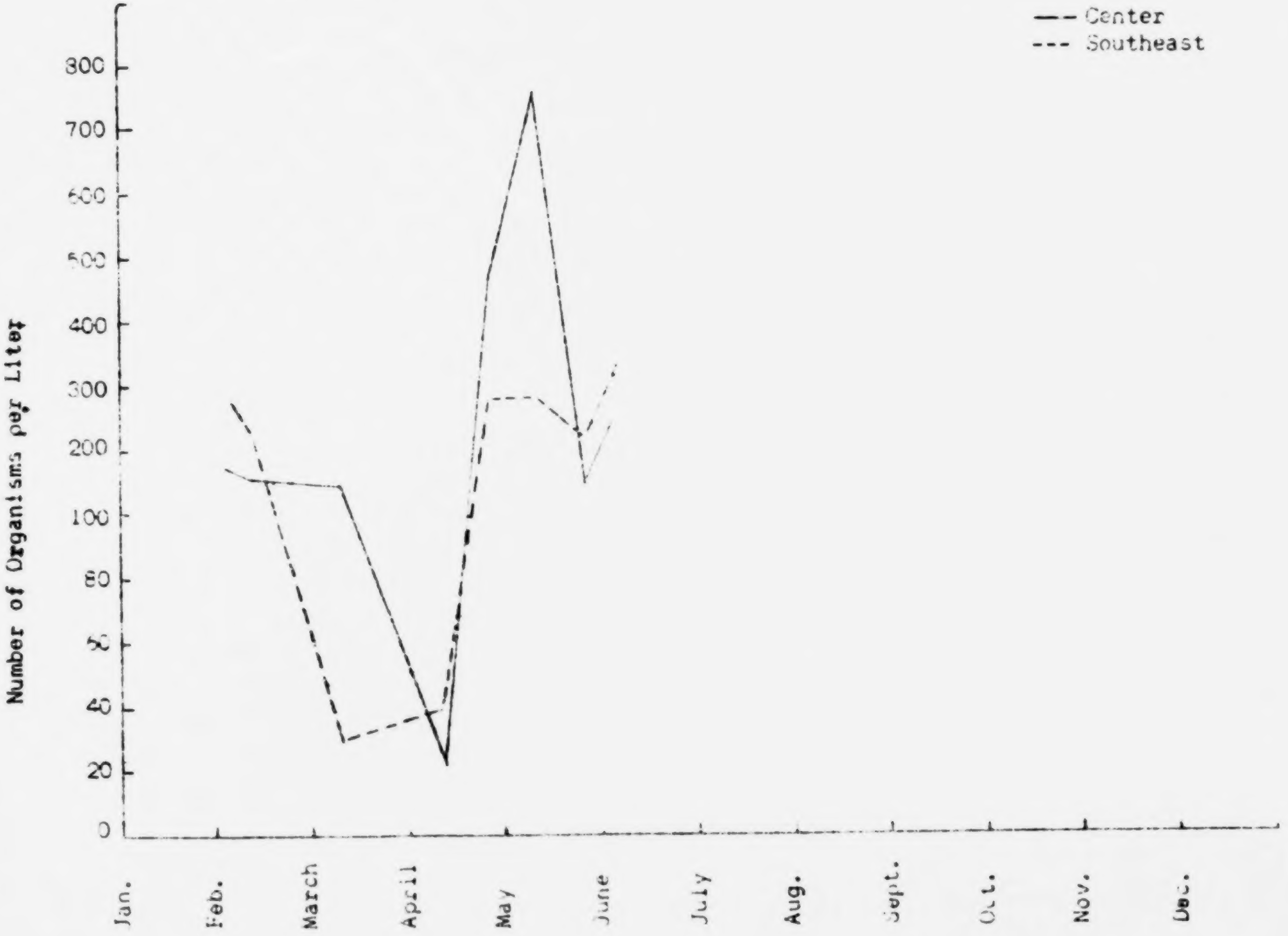


Figure 84. Variations in Population Densities of Cladocerans in Lake Herman During 1971

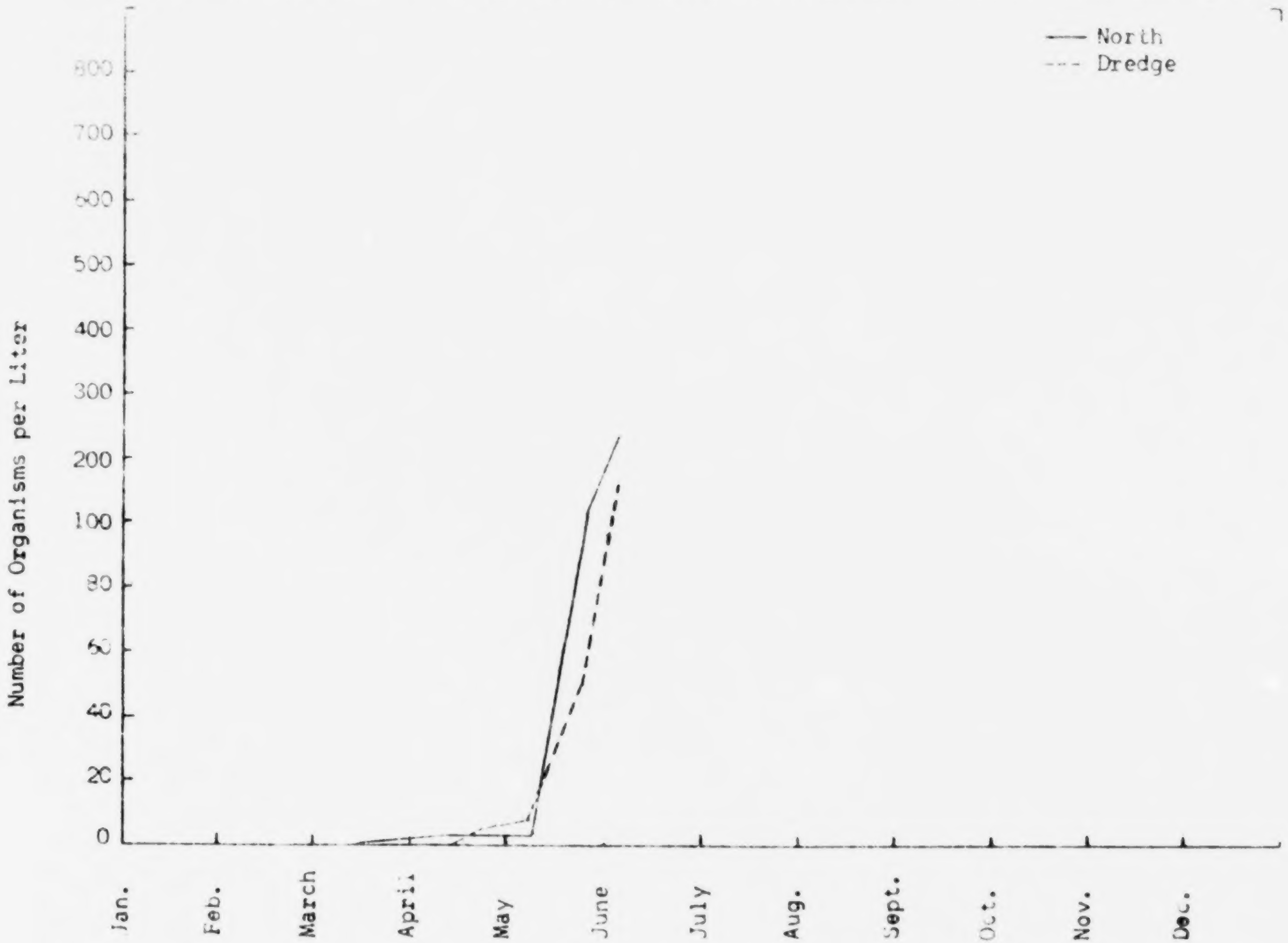


Figure 85. Variations in Population Densities of Cladocerans in Lake Herman During 1971

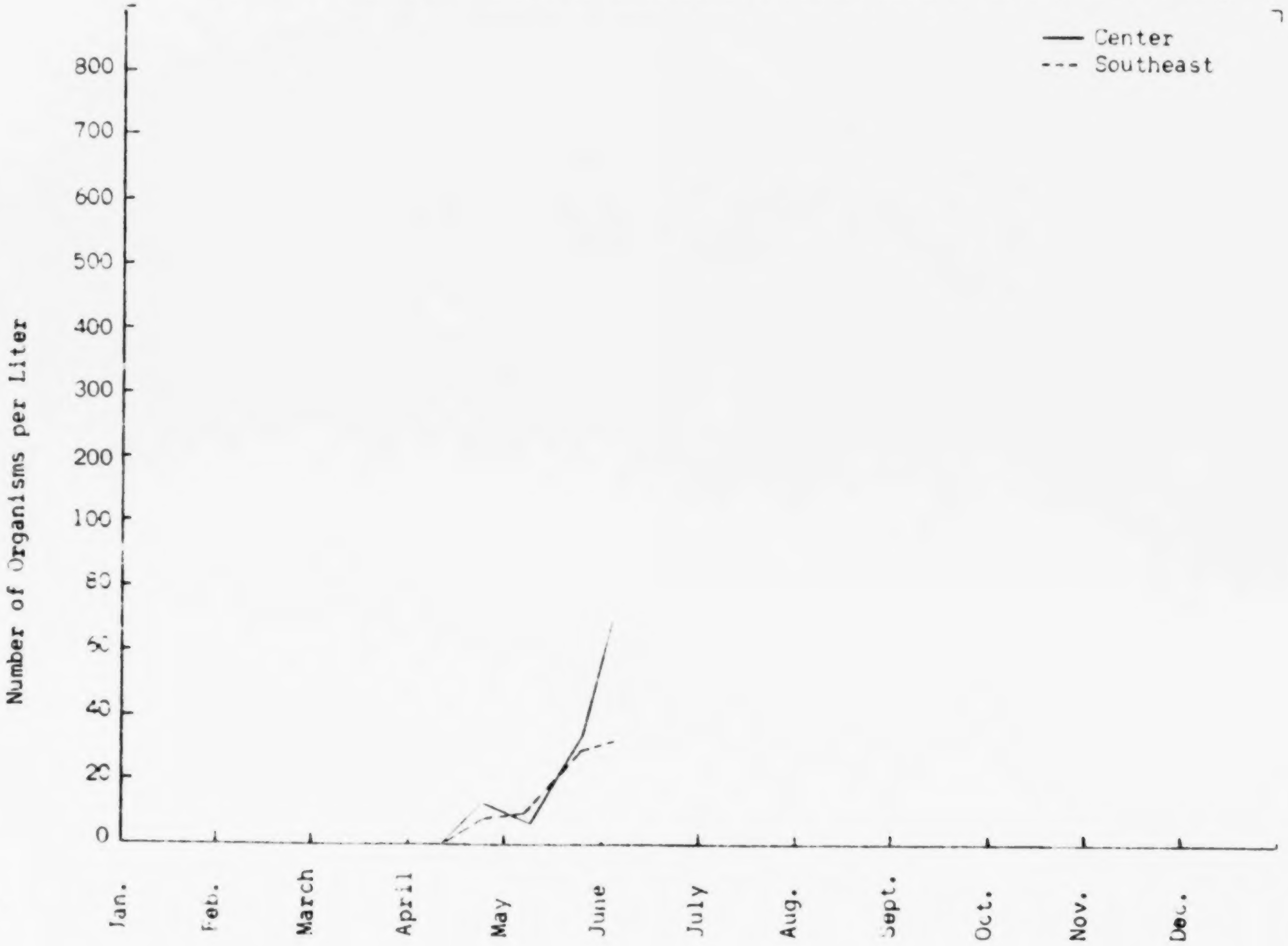
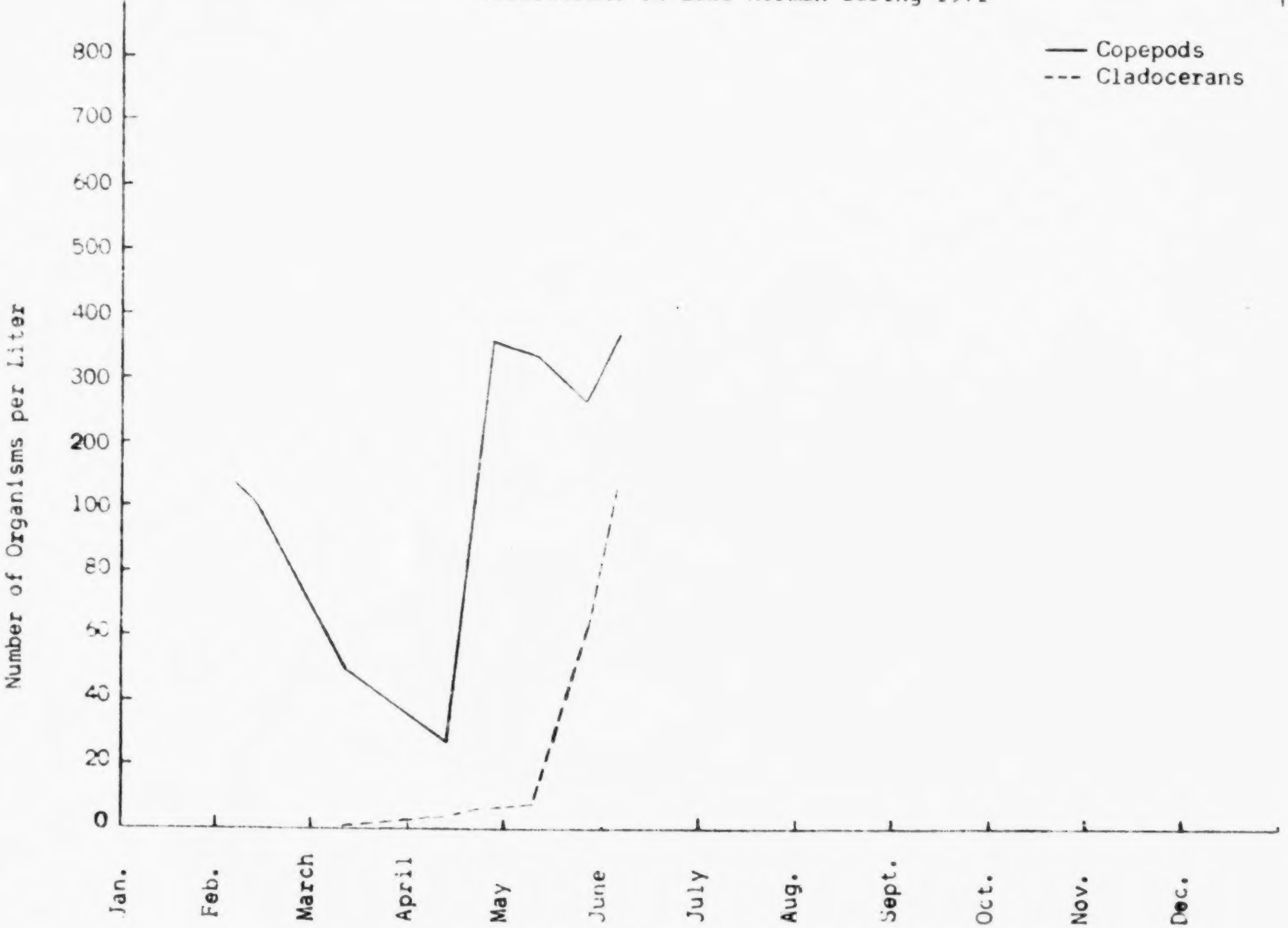


Figure 86. Variations in Average (Four Sites) Population Densities of Copepods and Cladocerans in Lake Herman During 1971



levels. The lack of biological growth was, however, reflected in lower pH values and higher alkalinity values during the summer of 1969 as opposed to other summers. Lake Madison experienced a fish kill during the 1969-1970 winter season. During the following summer of 1970, Lake Madison had its lowest density blooms which like Lake Herman the previous summer were accompanied by lower pH levels and higher alkalinity levels with no significant changes in phosphorus or nitrogen levels. We cannot explain this relationship between winter fish kill and lower summer plankton densities.

In terms of the chemical parameters the major differences in the two lakes occurred in the levels of chloride (Madison about 30X Herman), conductivity (Madison about 2X Herman) and sodium (Madison about 3X Herman). The explanation for these differences undoubtedly lies in the source water for the two lakes. Lake Madison, receiving the effluent from the sewage lagoon thus receives the city water which has been chlorinated and most of which has been softened with sodium chloride softeners. Lake Herman waters are, however, usually slightly more turbid than Lake Madison waters. This difference would arise from the shallowness of Lake Herman—the wind and wave action would be expected to stir up the sediments to a greater degree.

In terms of biological parameters, Lake Madison (sewage polluted lake) had a higher density of phytoplankton than Lake Herman (silt polluted lake), except during the summer of 1970 following the winter fish kill in Lake Madison. This higher density growth in Lake Madison cannot be explained in terms of the usual phosphorus and nitrogen levels because both lakes had an abundance of these nutrients. The extra growth probably results from sewage components not determined by analysis. Along this line, it is of interest to note that frequently the phytoplankton counts decrease in number in going from the west sampling site to the southeast sampling site in Lake Madison—paralleling the inlet of the sewage effluent and the lake outlet. As mentioned earlier phosphorus and nitrogen levels at the various sampling sites on Lake Madison also followed this same trend before the summer of 1970. At that time a meat packing plant which overloaded the city sewage treatment facility was closed.

Another point which should be mentioned is that the variety of species of both diatoms and blue-green algae present in significant quantity was much more restricted in the sewage polluted lake. For instance, the only diatom species occurring in any quantity in Lake Madison were *Cyclotella*, *Nitzschia* and *Stephanodiscus*. Lake Herman diatoms occurring in significant quantities included these three species in addition to *Surirella* and *Melosira*. In Lake Madison the only blue-green alga in abundance was *Aphanizomenon flos-aquae* with *Phormidium minnesotense* occurring sporadically. Lake Herman also contained high densities of *Aphanizomenon flos-aqua*, but *Anabena* and *Microcystis* were also important. These differences may result in part from the summer copper sulfate treatment of Lake Madison.

In order to retard soil erosion on the Lake Herman watershed a number of silt traps were constructed on the feeder streams. A gabion type of silt trap was selected because it is relatively inexpensive, can be constructed with a minimal amount of engineering advice, and does not permanently retain water. Basically, the resulting trap is a wire basket packed with rocks and placed in a creekbed. Figures 87 and 88 give a general idea of the appearance of gabion silt traps. These traps are described with regard to size, location and creekbed type in Appendix D.

The silt traps were found to be effective as coarse filtering devices. Figures 89 and 90 show two of the traps; note the debris collected against the upstream side of these traps. Analyses of water samples, collected just above and below the traps, for filtered solids and turbidity indicate that the traps had little if any effect as a silt filter. Some of these analytical results are listed in Table V. However, it was found that water far enough above the gabion to still be flowing rapidly showed a higher level of filtered solids and turbidity than the water samples collected just above or below the gabion (see Table V). Thus, it may be concluded that the gabions were effective in the sense that they retarded the flow of water, causing some of the silt load to be dropped. Since a high quantity of filtered solids is associated with high values of total phosphorus, the gabion silt traps may aid in decreasing the level of phosphorus reaching the lake. After the two or three light run-off years since most of the traps were constructed, there is only a deposit of one-half to three inches of silt behind six of the traps; but this amount could increase substantially after heavy run-offs like that occurring in the spring of 1969.

Whatever success was achieved by the silt traps was diminished by damage. Six of the traps had soil erosion around them; two of these are shown in Figures 91 and 92. These traps were all in creekbeds which lacked vegetative cover, and most of them were partially countersunk in the creekbed. The traps had been placed intentionally in eroded creekbeds with the hope that they would stop further erosion and allow silt to fill the eroded areas. Apparently, pressure from water backed-up behind a silt trap caused the water to break through at any weak point. Once a small hole was formed under or at the side of a trap, it was soon enlarged by increased water movement through this area. The placement of gabion silt traps in eroded creekbeds and countersinking measures should be avoided.

The three traps built in 1970 were constructed with aprons to protect the creek bottom against erosion (see Figures 93 and 94) and were constructed in well-sodded creekbeds. These traps have not been damaged by soil erosion. However, it is felt that the amount of run-off since their construction has not been sufficient to test adequately these features. It should be noted that no silt has been deposited behind these traps, which is probably best explained at this time by small amounts of run-off during the past year.

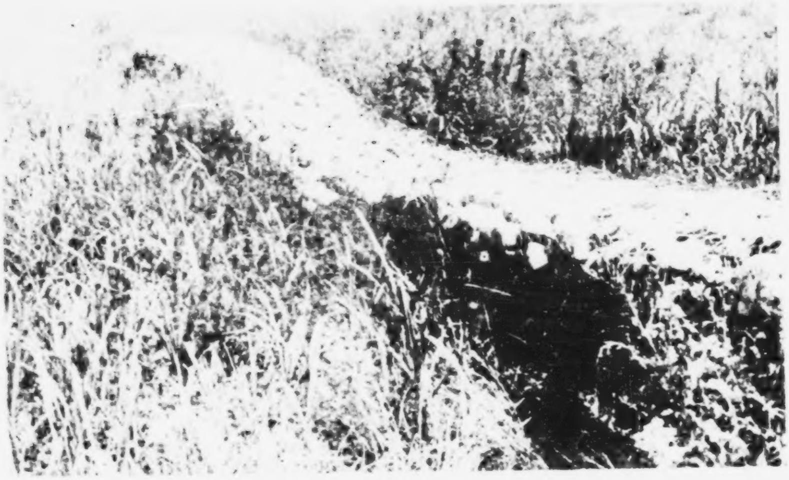


Figure 87. Silt Trap No. 1.

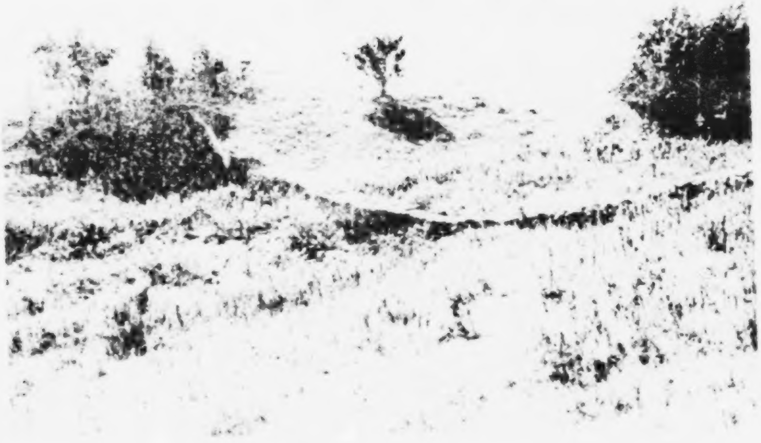


Figure 88. Silt Trap No. 1a.

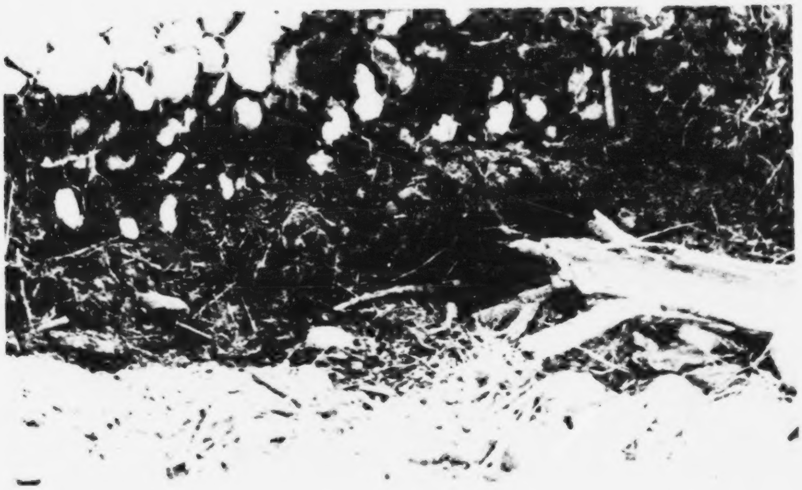


Figure 89. Silt Trap No. 4 with debris collected along upstream face.

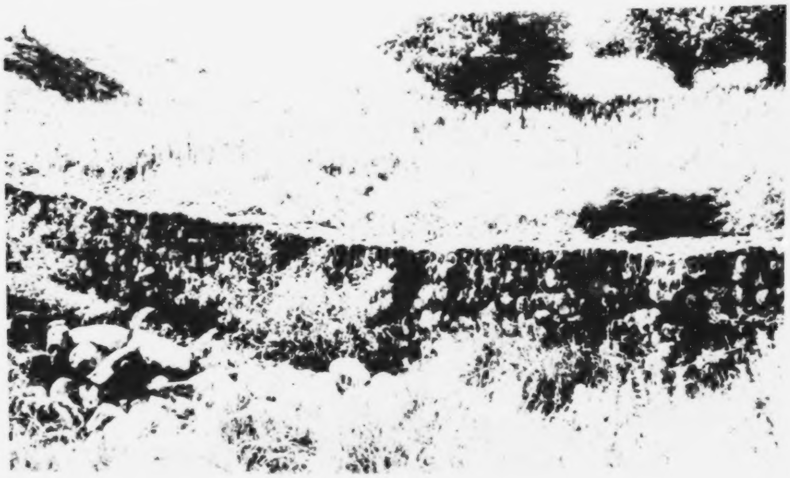


Figure 90. Silt Trap No. 13 with debris collected along upstream face.

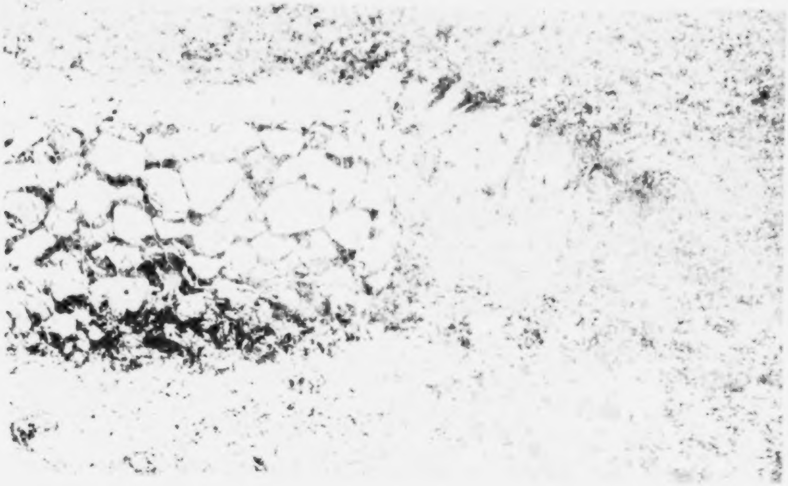


Figure 91. Silt Trap No. 9 with side [illegible] (flanking).

Figure 92. Silt Trap No. 10 with erosion (undercutting).

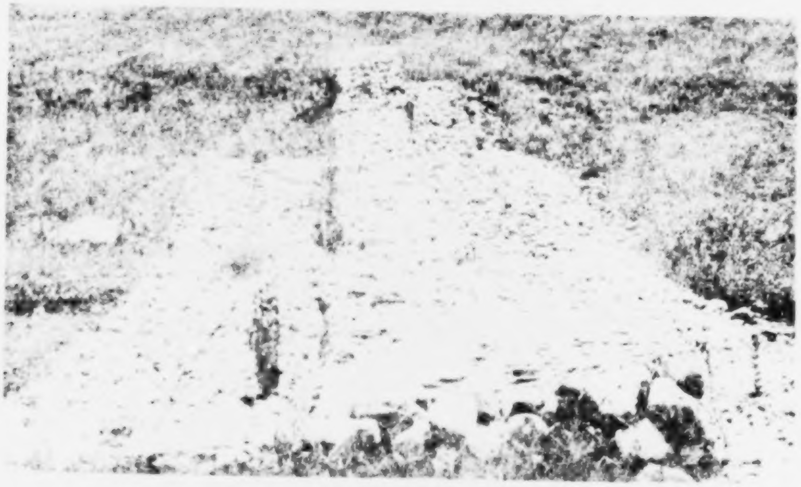


Figure 93. Silt Trap No. 16 with upstream and downstream aprons.

Figure 94. Silt Trap No. 17 with downstream apron.

Table V Measurements on Water Above and Below Gabion Silt Traps

| Date and Location | Filtered Solids grams/liter | Turbidity Jackson Units |
|---|---|---|
| April 4, 1970 | | |
| Water Running off field above Gabion 4 | 2.525 | 391 |
| Water about 15 Yards above Gabion 4 | 0.085 | 231 |
| Water just Above Gabion 4 | 0.066 | 223 |
| March 11, 1970 | | |
| Just above Gabion 15 | 0.0446 | 36.5 |
| Between Gabions 15 and 16 | 0.0475 | 38.6 |
| Just below Gabion 16 | 0.0403 | 39.1 |

All in all, a relatively low level of success seems to have been obtained by the gabion-type of silt traps. It seems likely that those which are not rendered ineffective by erosion will retain some silt over a period of years. However, more effective types of silt traps and perhaps other changes are needed if most of the soil erosion on the Lake Herman watershed is to be halted.

## SECTION VII

## ACKNOWLEDGMENTS

The support of Dakota State College is acknowledged with sincere thanks. The encouragement and aid of Dr. Harry P. Bowes, President of Dakota State College, and Dr. Clyde K. Brashier, Chairman of the Division of Science and Mathematics, have made this project possible.

Dr. Robert Anderson, Professor of Biology at the University of Missouri at Kansas City, has served as a consultant on algal identification and was generous in his advice on several aspects of this project. Robert Buckman and Robert Herting served as directors of the silt trap construction team during the summer of 1969 and 1970 respectively. Karla Wickre has typed this report.

The directors extend a very special thanks to their research assistants who have carried out the bulk of this work—Charles Rohrer, Robert Williams, Jerome Jensen, and Andreas Nielson. Charles Rohrer has developed many of the chemical analytical methods described and prepared parts of this report.

The support of the project by the Environmental Protection Agency and the help provided by Mr. Arnold Gahler, Grant Project Officer, is also acknowledged with sincere thanks.

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# SECTION [illegible]

## [illegible]

1. Anderson, [illegible]. [illegible] Laboratories. [illegible] Protection Agency [illegible]

2. FWPCA, [illegible] Research Program, [illegible] Department of the Interior, [illegible]

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# SECTION IX

## APPENDICES

Page No.

A. Results of Chemical Analyses of Lake Madison . . . . . . . . . 136

B. Results of Chemical Analyses of Lake Madison Tributaries . . 158

C. Results of Chemical Analyses of Lake Herman . . . . . . . . . 169

D. Description of Silt Traps and Silt Trap Sites . . . . . . . . 193

## Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity ppm NaCl | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June, 1968 | 8.2 | 196 | | | | | | | | | 0.0* | |
| July | 8.6 | 143 | 11.12 | | | | | | 0.49 | 3 | 0.0 | |
| August | | 146 | 12.01 | | | | | | 1.38 | 3.4 | | |
| September | 8.1 | 147 | 8.4 | | | 174.3 | | | 0.95 | 0.93 | 1.12 | |
| October | 7.4 | 163 | 9.4 | | | 167.7 | | | 0.80 | 1.14 | 2 | |
| December | 7.6 | 142 | 6.7 | | | 193 | | | 0.77 | 2.53 | 1.05 | |
| Jan., 1969 | 7.45 | 231 | 4.6 | | | 197 | | | 0.68 | 2.81 | 0.338 | |
| February | 8.7 | 136 | 2.4 | | | 175.5 | | | 0.58 | 1.5 | 1.93 | |
| March | 8.2 | 114 | [illegible] | | | 176.5 | — | | 0.625 | 1.50 | 2.05 | |
| June 13 West | 7.8 | 145 | 7.9 | | 710 | 118.5 | | | 1.05 | 0.30 | 0.125 | |
| 24 | 7.8 | 140 | 10.45 | | 725 | 116 | | | 0.56 | 0.58 | 0.09 | |

*All nitrate values from June, 1968, through August 20, 1969, are actually nitrate plus nitrite determined according to Page 41 of the Hach Manual.

## Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3/1$ | Dissolved Oxygen mg $O_2/1$ | COD mg/1 | Conductivity ppm NaCl | Chloride mg Cl/1 | Silica mg $SiO_2/1$ | Ortho Phosphate mg $PO_4/1$ | Total Phosphorus mg $PO_4/1$ | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1 | | | | | | | | | | | | |
| Southeast | 7.7 | 139 | 15.2 | | 750 | 115.5 | | | 0.49 | 0.18 | 0.10 | |
| 8 | | | | | | | | | | | | |
| Southeast | 8.8 | 129 | 13.05 | | 520 | | | | 0.35 | 0.51 | 0.01 | |
| 15 | | | | | | | | | | | | |
| West | 8.50 | 138 | 12.1 | | 750 | 119 | | | 0.48 | 0.40 | 0.00 | |
| Center | 8.73 | 131 | 12.75 | | 735 | 119.9 | | | 0.48 | 0.23 | 0.00 | |
| Southeast | 8.65 | 126 | 14.4 | | 740 | 116.4 | | | 0.39 | 0.50 | 0.00 | |
| 22 | | | | | | | | | | | | |
| **West** | 8.35 | 138 | 8.9 | | 695 | 120.8 | | | 0.64 | 0.60 | 0.012 | |
| Center | 8.9 | 134 | 10.1 | | 693 | 118.1 | | | 0.57 | 0.46 | 0.00 | |
| Southeast | 8.5 | 135 | 8.1 | | 690 | 118.9 | | | 0.50 | 0.45 | 0.001 | |
| 29 | | | | | | | | | | | | |
| West | 8.50 | 130 | 9.4 | | 725 | 122.7 | | | 0.40 | 0.36 | 0.00 | |
| Center | 8.7 | 130 | 11.2 | | 700 | 121.0 | | | 0.36 | 0.32 | 0.00 | |
| Southeast | 8.9 | [illegible] | 10.0 | | 695 | 120.8 | | | 0.32 | 0.28 | 0.00 | |
| Aug. 5 | | | | | | | | | | | | |
| West | 8.95 | [illegible] | [illegible] | | [illegible] | 122 | | | [illegible] | [illegible] | [illegible] | |
| Center | 9.0 | [illegible] | 12.[illegible] | | 770 | 121 | | | 0.40 | 0.40 | [illegible] | |
| Southeast | 8.7 | 120 | 11.45 | | 800 | 119 | | | [illegible] | 0.2[illegible] | 0.00 | |

## Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity ppm NaCl | Chloride mg Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite µg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 14, 1969 | | | | | | | | | | | | |
| West | 8.8 | 135 | 10.2 | | 750 | 122 | | | 0.64 | 0.32 | 0.053 | |
| Center | 8.9 | 132 | 9.4 | | 740 | 119 | | | 0.54 | 0.37 | 0.040 | |
| Southeast | 9.1 | 130 | 12.5 | | 720 | 118 | | | 0.35 | 0.33 | 0.053 | |
| 20 | | | | | | | | | | | | |
| West | 8.75 | 140 | 10.4 | | 845 | 122 | | | 0.64 | 1.97 | 0.10 | |
| Center | 8.78 | 136 | 9.7 | | 885 | 120 | | | 0.56 | 2.72 | 0.11 | |
| Southeast | 8.74 | 143 | 9.9 | | 855 | 119 | | | 0.46 | 1.91 | 0.11 | |
| 26 | | | | | | | | | | | | |
| West | 9.4 | 136 | 12.8 | | 770 | 122 | | | 0.68 | 2.65 | 0.00* | |
| Center | 9.0 | 139 | 11.2 | | 750 | 120 | | | 0.43 | 2.67 | 0.00 | |
| Southeast | 8.45 | 134 | 8.40 | | 730 | 119 | | | 0.40 | 2.07 | 0.00 | |
| Sept. 12 | | | | | | | | | | | | |
| West | 8.5 | 147 | 6.9 | | 795 | 125 | | | 0.72 | 0.70 | 0.14 | |
| Center | 8.6 | 140 | 8.75 | | 780 | 123 | | | 0.57 | 0.81 | 0.11 | |
| Southeast | 8.7 | 140 | 9.0 | | 745 | 134 | | | 0.40 | 0.66 | 0.07 | |
| 27 | | | | | | | | | | | | |
| West | 8.6 | 151 | 8.8 | | 775 | 129.2 | | | 0.60 | 0.77 | 0.25 | 18.7 |
| Center | 8.7 | 147 | 11.3 | | 760 | 125.4 | | | 0.58 | 0.77 | 0.00 | 15.5 |
| Southeast | 8.6 | 150 | 10.0 | | 760 | 127.3 | | | 0.50 | 0.84 | 0.16 | 12.3 |

*Beginning with this value all nitrate values were determined according to the FWPCA Manual method.

Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3/1$ | Dissolved Oxygen mg $O_2/1$ | COD mg/1 | Conductivity ppm NaCl | Chloride mg Cl/1 | Silica mg $SiO_2/1$ | Ortho Phosphate mg $PO_4/1$ | Total Phosphorus mg $PO_4/1$ | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 14, 1969 | | | | | | | | | | | | |
| West | 8.7 | 155 | 13.5 | | 780 | 126.3 | | | 0.55 | | 0.046 | 22.7 |
| Center | 8.72 | 154 | 13.0 | | 790 | 127.3 | | | 0.48 | | 0.025 | 23.0 |
| Southeast | 8.75 | 154 | 12.0 | | 790 | 125.4 | | | 0.41 | | 0.030 | 28.2 |
| 26 | | | | | | | | | | | | |
| West | 8.76 | 154 | 13.7 | | 750 | 190 | | 0.11 | 0.81 | | | 17.6 |
| Center | 8.71 | 155 | 13.95 | | 745 | 203 | | 0.07 | 0.45 | | 0.16 | 9.66 |
| Southeast | 8.72 | 157 | 11.1 | | 740 | 212 | | 0.05 | 0.34 | | 0.162 | 8.82 |
| Nov. 9 | | | | | | | | | | | | |
| West | 8.7 | 143 | 15.2 | | 1610* | 124 | | 0.05 | 0.37 | | 0.025 | 9.24 |
| Center | 8.7 | 156 | 13.4 | | 1610 | 122 | | 0.06 | 0.25 | | 0.022 | 16.0 |
| Southeast | 8.7 | 156 | 10.8 | | 1600 | 122 | | 0.05 | 0.24 | | 0.052 | 16.8 |
| Dec. 14 | | | | | | | | | | | | |
| West | 8.6 | 154 | 15.7 | | 1750 | 143 | | 0.10 | 0.46 | | 0.072 | 2.90 |
| Center | 8.5 | 165 | 7.7 | | 1720 | 133 | | 0.20 | 0.25 | | 0.05 | 5.22 |
| Southeast | 8.45 | 165 | 9.4 | | 1730 | 134 | | 0.21 | 0.19 | | 0.038 | 4.35 |

*Starting with this sample, all further conductivities were determined according to the procedure in the FWPCA Manual and are expressed in µmhos/cm at 25° C.

Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite µg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 4, 1970 | | | | | | | | | | | | |
| West | 8.4 | 173 | 7.4 | | 1830 | 152 | 3.8 | 0.57 | 0.70 | 0.72 | 0.62 | 9.1 |
| 14 | | | | | | | | | | | | |
| West | 7.89 | 177 | 3.25 | | 1870 | 164 | 3.67 | 0.67 | 0.72 | 0.68 | 0.05 | 5.17 |
| Center | 7.90 | 175 | 2.2 | | 1770 | 155 | 4.47 | 0.43 | 0.48 | 0.42 | 0.02 | 6.12 |
| Southeast | 7.86 | 172 | | | 1740 | 143 | 3.70 | 0.34 | 0.34 | 0.31 | 0.05 | 6.64 |
| 27 | | | | | | | | | | | | |
| West | 7.83 | 186 | 1.8 | | 1911 | 171 | 4.39 | | 0.78 | 2.94 | 0.010 | 7.18 |
| Center | 7.87 | 179 | 0.25 | | 1807 | 153 | 5.34 | | 0.49 | 3.05 | 0.082 | 6.11 |
| Southeast | 7.87 | 175 | 0.9 | | 1776 | 148 | 5.27 | | 0.38 | 2.02 | 0.030 | 7.29 |
| Feb. 14 | | | | | | | | | | | | |
| West | 7.70 | 186 | 1.1 | | 1911 | 159 | 5.00 | 0.81 | 0.92 | 1.81 | 0.00 | 10.6 |
| Center | 7.75 | 182 | | | 1859 | 152 | 5.23 | 0.56 | 0.65 | 1.87 | 0.040 | 16.3 |
| Southeast | 7.68 | 180 | | | 1818 | 154 | 5.15 | 0.52 | 0.57 | 0.94 | 0.022 | 7.9 |
| March14 | | | | | | | | | | | | |
| West | 8.20 | 71 | 3.1 | | 624 | 61.6 | 7.34 | 1.09 | 1.92 | | 0.695 | 107.1 |
| Center | 7.00 | 90 | 2.9 | | 788 | 76.0 | 6.30 | 1.45 | 1.70 | | 0.760 | 371.8 |
| Southeast | 7.32 | 122 | 1.3 | | 1239 | 102 | 3.87 | 0.98 | 1.01 | | 0.065 | 25.5 |

Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg CaCO$_3$/l | Dissolved Oxygen mg O$_2$/l | COD mg/l | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/l | Silica mg SiO$_2$/l | Ortho Phosphate mg PO$_4$/l | Total Phosphorus mg PO$_4$/l | Ammonia mg NH$_3$-N/l | Nitrate mg NO$_3$-N/l | Nitrite µg NO$_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April24 | | | | | | | | | | | | |
| West | 8.88 | 150 | 15.6 | 44.5 | | 109 | 0.85 | 0.33 | 0.78 | 0.29 | 0.168 | 11.3 |
| Center | 8.93 | 150 | 14.5 | 52.4 | | 121 | 0.77 | 0.38 | 1.43 | 0.24 | 0.100 | 9.4 |
| Southeast | 8.93 | 131 | 13.5 | | | 123 | 0.45 | 0.47 | 0.93 | 0.28 | 0.125 | 7.6 |
| May 8, 1970 | | | | | | | | | | | | |
| West | 8.80 | 147 | 8.8 | | | 117 | 1.28 | 0.29 | 0.42 | 0.26 | 0.059 | 3.4 |
| Center | 8.82 | 148 | 9.0 | | | 121 | 0.34 | 0.29 | 0.48 | 0.22 | 0.045 | 3.1 |
| Southeast | 8.87 | 148 | 8.6 | | | 126 | 0.49 | 0.28 | 0.43 | 0.23 | 0.045 | 4.6 |
| 28 | | | | | | | | | | | | |
| West | 7.97 | 176 | 6.9 | 36.2 | 1470 | 120 | 6.5 | | 0.72 | 1.14 | 0.20 | 37.0 |
| Center | 7.97 | 170 | 7.1 | 36.8 | 1480 | 123 | 7.1 | | 0.71 | 1.00 | 0.28 | 50.2 |
| June 5 | | | | | | | | | | | | |
| West | 7.67 | 180 | 4.05 | 29.7 | 1470 | 118 | 8.5 | 0.54 | 0.78 | 1.38 | 0.466 | 41.9 |
| Center | 7.68 | 175 | 4.5 | 32.5 | 1540 | 119 | 9.5 | 0.48 | 0.73 | 1.21 | 0.128 | 44.0 |
| Southeast | 7.67 | 175 | 6.1 | 31.0 | 1530 | 115 | 9.5 | 0.50 | 0.75 | 1.03 | 0.198 | 53.7 |
| 11 | | | | | | | | | | | | |
| West | 7.80 | 180 | 4.9 | 28.2 | 1540 | 122 | 10.8 | 0.35 | 0.43 | 1.32 | 0.104 | 59.5 |
| Center | 7.80 | 174 | 5.5 | 33.3 | 1520 | 122 | 11.3 | 0.37 | 0.63 | 1.18 | 0.115 | 69.0 |
| Southeast | 7.73 | 172 | 5.1 | 27.1 | 1500 | 115 | 12.2 | 0.43 | 0.44 | 1.37 | 0.110 | 55.8 |

Appendix A  Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity μmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite μg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June 18, 1970 | | | | | | | | | | | | |
| West | 7.70 | 170 | 4.00 | 46.0 | 1558 | 128 | 12.6 | 0.26 | 0.35 | 1.20 | 0.140 | 69.4 |
| Center | 7.69 | 165 | 5.30 | 50.4 | 1517 | 123 | 14.5 | 0.26 | 0.41 | 1.08 | 0.196 | 54.8 |
| Southeast | 7.68 | 166 | 5.90 | 41.5 | 1506 | 123 | 15.2 | 0.34 | 0.45 | 1.20 | 0.131 | 51.5 |
| July 1 | | | | | | | | | | | | |
| West | 8.20 | 169 | 6.4 | 69.2 | 1579 | 121 | 17.9 | 0.13 | 0.27 | 0.18 | 0.00 | 3.04 |
| Center | 8.10 | 166 | 7.6 | 47.1 | 1548 | 114 | 17.4 | 0.13 | 0.20 | 0.14 | 0.0175 | 3.49 |
| Southeast | 8.00 | 162 | 7.75 | 66.3 | 1531 | 112 | 18.4 | 0.16 | 0.22 | 0.18 | 0.2025 | 10.14 |
| 7 | | | | | | | | | | | | |
| West | 8.30 | 166 | 9.1 | | 1600 | 134 | 19.8 | 0.18 | 0.31 | 0.22 | 0.158 | 1.53 |
| Center | 8.23 | 163 | 7.8 | | 1569 | 125 | 21.1 | 0.16 | 0.33 | 0.00 | 0.00 | 1.09 |
| Southeast | 8.11 | 161 | 6.8 | | 1558 | 121 | 21.4 | 0.20 | 0.29 | 0.02 | 0.011 | 2.17 |
| 14 | | | | | | | | | | | | |
| West | 8.56 | 166 | 11.1 | | 1598 | 131 | 22.5 | 0.39 | 0.50 | 0.27 | | 2.78 |
| Center | 8.45 | 163 | 9.6 | | 1598 | 128 | 22.5 | 0.25 | 0.35 | 0.27 | 0.00 | 1.77 |
| Southeast | 8.25 | 162 | 8.5 | | 1588 | 127 | 23.7 | 0.27 | 0.33 | 0.28 | 0.025 | 3.33 |
| 21 | | | | | | | | | | | | |
| West | 8.20 | 161 | 7.8 | | 1629 | 134 | 24.9 | 0.38 | 0.54 | 0.19 | 0.00 | 3.2 |
| Center | 8.12 | 162 | 6.6 | | 1619 | 134 | 22.9 | 0.37 | 0.48 | 0.10 | 0.00 | 2.6 |
| Southeast | 8.02 | 161 | 6.9 | | 1609 | 130 | 26.9 | 0.37 | 0.48 | 0.31 | 0.01 | 2.0 |

Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite µg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 28, 1970 | | | | | | | | | | | | |
| West | 8.52 | 161 | 10.9 | | 1617 | 141 | 26.0 | 0.32 | 0.38 | 0.06 | | 1.46 |
| Center | 8.30 | 162 | 8.4 | | 1607 | 141 | 27.7 | 0.33 | 0.33 | 0.10 | 0.00 | 1.68 |
| Southeast | 8.19 | 163 | 9.65 | | 1607 | 136 | 27.8 | 0.34 | 0.35 | 0.14 | 0.02 | 1.46 |
| Aug. 4 | | | | | | | | | | | | |
| West | 8.16 | 179 | 5.2 | >55.0 | 1669 | 140 | 30.7 | 0.63 | 0.79 | 1.46 | 0.03 | 9.02 |
| Center | 7.87 | 173 | 4.35 | 45.0 | 1648 | 138 | 31.2 | 0.58 | 0.58 | 1.92 | 0.02 | 4.47 |
| Southeast | 7.75 | 172 | 3.75 | >55.0 | 1638 | 138 | 31.7 | 0.61 | 0.61 | 1.70 | 0.00 | 5.64 |
| 11 | | | | | | | | | | | | |
| West | 8.74 | 166 | 14.7 | 139 | 1597 | 149 | 25.8 | 0.09 | 0.18 | 0.51 | 0.00 | 5.68 |
| Center | 8.33 | 168 | 9.9 | 126 | 1617 | 144 | 30.5 | 0.26 | 0.31 | 0.48 | 0.03 | 8.48 |
| Southeast | 8.09 | 170 | 6.9 | 50.6 | 1628 | 141 | 28.4 | 0.37 | 0.37 | 0.93 | 0.07 | 11.7 |
| 18 | | | | | | | | | | | | |
| West | 7.99 | 166 | 6.0 | 55.5 | 1653 | 123 | 31.5 | 0.33 | 0.72 | 0.16 | 0.002 | 3.16 |
| Center | 7.98 | 167 | 5.5 | 56.9 | 1663 | 125 | 20.0 | 0.29 | 0.48 | 0.20 | 0.003 | 4.09 |
| Southeast | 7.80 | 168 | 6.0 | 40.4 | 1653 | 123 | 33.3 | 0.40 | 0.52 | 0.44 | 0.013 | 6.54 |
| Sept. 3 | | | | | | | | | | | | |
| West | 8.13 | 170 | 12.6 | 54.2 | 1695 | 139 | 29.4 | 0.43 | 0.68 | 0.52 | 0.099 | 5.83 |
| Center | 7.90 | 170 | 8.5 | 38.9 | 1685 | 133 | 30.3 | 0.43 | 0.43 | 0.48 | 0.020 | 4.95 |
| Southeast | 7.62 | 171 | 14.2 | 35.5 | 1675 | 133 | 28.7 | 0.54 | 0.54 | 0.65 | 0.014 | 4.74 |

Appendix A Results of Chemical Analysis of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3/1$ | Dissolved Oxygen mg $O_2/1$ | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2/1$ | Ortho Phosphate mg $PO_4/1$ | Total Phosphorus mg $PO_4/1$ | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sept. 22, 1970 | | | | | | | | | | | | |
| West | 8.23 | 169 | 6.0 | 42.2 | 1701 | 141 | 29.2 | 0.12 | 0.26 | 0.16 | 0.047 | 2.12 |
| Center | 8.23 | 170 | 7.1 | 31.9 | 1661 | 138 | 30.5 | 0.20 | 0.27 | 0.17 | 0.082 | 1.87 |
| Southeast | 8.31 | 170 | 6.9 | 32.6 | 1651 | 152 | 31.1 | 0.21 | 0.26 | 0.16 | 0.088 | 2.02 |
| Oct. 6 | | | | | | | | | | | | |
| West | 8.31 | 175 | 8.1 | 36.3 | 1787 | 145 | 28.3 | 0.095 | 0.20 | 0.09 | 0.030 | 1.97 |
| Center | 8.40 | 174 | 8.5 | 39.0 | 1766 | 147 | 27.0 | 0.13 | 0.20 | 0.08 | 0.028 | 1.21 |
| Southeast | 8.38 | 174 | 8.9 | 34.2 | 1755 | 147 | 30.1 | 0.19 | 0.19 | 0.07 | 0.028 | 1.21 |
| 21 | | | | | | | | | | | | |
| West | 8.31 | 164 | 9.9 | 32.6 | 1787 | 142 | 16.0 | 0.093 | 0.20 | 0.07 | 0.06 | 4.44 |
| Center | 8.22 | 167 | 10.0 | 32.1 | 1628 | 152 | 15.6 | 0.091 | 0.21 | 0.08 | 0.084 | 3.55 |
| Southeast | 8.40 | 169 | 10.6 | 31.3 | 1797 | 142 | 25.4 | 0.16 | 0.30 | 0.06 | 0.11 | 8.92 |
| Nov. 3 | | | | | | | | | | | | |
| West | 8.22 | 168 | | 33.0 | 1776 | 207 | 14.3 | 0.13 | 0.26 | 0.32 | 0.134 | 3.33 |
| Center | 8.32 | 167 | 11.8 | 36.3 | 1766 | 186 | 21.3 | 0.16 | 0.34 | 0.35 | 0.089 | 3.10 |
| Southeast | 8.35 | 167 | 11.9 | 33.0 | 1736 | 199 | 19.5 | 0.15 | 0.34 | 0.18 | 0.086 | 2.22 |
| Dec. 19 | | | | | | | | | | | | |
| West | 8.12 | 183 | 12.8 | 35.0 | 1813 | 160 | 19.5 | 0.12 | 0.16 | 1.00 | 0.213 | 1.11 |
| Center | 8.10 | 177 | 12.2 | 32.0 | 1823 | 156 | 23.0 | 0.17 | 0.17 | 0.14 | 0.148 | 1.99 |
| Southeast | 8.20 | 157 | 12.8 | 28.3 | 1603 | 134 | 15.3 | 0.09 | 0.11 | 0.21 | 0.225 | 1.66 |

## Appendix A  Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 19, 1971 | | | | | | | | | | | | |
| West | 7.94 | 194 | 11.7 | 38.8 | 1814 | 178 | 30.1 | 0.18 | | 0.25 | 0.23 | 4.12 |
| Center | 7.85 | 192 | 9.7 | 34.5 | 1805 | 168 | 44.1 | 0.17 | | 0.27 | 0.16 | 5.52 |
| Southeast | 7.72 | 189 | 7.2 | 30.2 | 1964 | 161 | 32.4 | 0.18 | 0.20 | 0.30 | 0.13 | 2.59 |
| Feb. 12 | | | | | | | | | | | | |
| West | 7.66 | 210 | 9.6 | 39.7 | 1528 | 183 | 32.4 | 0.19 | 0.23 | 0.37 | 0.228 | 2.38 |
| Center | 7.63 | 202 | 6.5 | 34.8 | 1528 | 170 | 30.1 | 0.20 | 0.22 | 0.50 | 0.183 | 2.25 |
| Southeast | 7.51 | 202 | 5.6 | 32.8 | 1528 | 163 | 28.9 | 0.20 | 0.22 | 0.52 | 0.207 | 3.01 |
| March 5 | | | | | | | | | | | | |
| West | 7.41 | 190 | 4.8 | 43.0 | 1530 | 209.2 | 25.3 | 2.64 | 3.06 | 2.05 | 0.390 | 39.9 |
| Center | 7.51 | 193 | 2.0 | 41.9 | 1440 | 147 | 28.0 | 0.40 | 0.45 | 0.51 | 0.387 | 16.9 |
| Southeast | 7.62 | 201 | 5.2 | 36.8 | 1620 | 165 | 29.1 | 0.21 | 0.24 | 0.50 | 0.128 | 3.9 |
| April 12 | | | | | | | | | | | | |
| West | 8.60 | 148 | 13.4 | 30.1 | 1551 | 140.5 | 14.4 | 0.00 | 0.26 | 0.05 | 0.028 | 12 |
| Center | 8.38 | 149 | 14.0 | 27.0 | 1610 | 124.1 | 18.0 | 0.001 | 0.18 | 0.02 | 0.140 | 10 |
| Southeast | 8.32 | 148 | 13.5 | 27.3 | 1620 | 126.5 | 18.0 | 0.001 | 0.14 | 0.02 | 0.010 | 10 |
| 30 | | | | | | | | | | | | |
| West | 8.10 | 148 | 9.2 | 34.0 | 1582 | 130 | 15.5 | 0.097 | 0.12 | 0.15 | 0.02 | 35.0 |
| Center | 8.09 | 148 | 9.8 | 30.6 | 1612 | 132 | 17.8 | 0.050 | 0.11 | 0.12 | 0.03 | 12.0 |
| Southeast | 8.13 | 149 | 10.2 | 30.4 | 1622 | 132 | 18.5 | 0.043 | 0.09 | 0.08 | 0.01 | 12.0 |

## Appendix A Results of Chemical Analyses of Lake Madison

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 12, 1971 | | | | | | | | | | | | |
| West | 8.16 | 155 | 9.58 | 27.6 | 1620 | 67.7 | 21.1 | 0.10 | 0.10 | 0.09 | 0.08 | 5 |
| Center | 8.12 | 155 | 9.9 | 28.6 | 1630 | 67.9 | 18.2 | 0.10 | 0.12 | 0.12 | 0.08 | 4 |
| Southeast | 8.18 | 153 | 10.7 | 24.3 | 1640 | 67.2 | 12.9 | 0.07 | 0.07 | 0.08 | 0.04 | 1 |
| 27 | | | | | | | | | | | | |
| West | 8.24 | 153 | 9.1 | 35.5 | 1620 | 135.6 | 17.5 | 0.14 | 0.14 | 0.31 | 0.049 | 12 |
| Center | 8.28 | 153 | 9.2 | 35.8 | 1620 | 134.3 | 16.2 | 0.09 | 0.09 | 0.16 | 0.027 | 4 |
| Southeast | 8.34 | 153 | 9.5 | 30.4 | 1620 | 134.3 | 16.6 | 0.08 | 0.08 | 0.14 | 0.032 | 6 |

Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C. | Depth of Water (Feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June, 1968 | 21.5 | | | | 735 | | | | | | | |
| July | 23.4 | | | | 660 | | | | | | | |
| August | | | | | 648 | | | | | | | |
| September | 17.8 | | 77 | | 691 | | | | | | | |
| October | 14 | | 85 | | 682 | | | | | | | |
| December | 0 | | | | 742 | | | | | | | |
| Jan., 1969 | 1 | | | | 910 | | | | | | | |
| February | | | | | 864 | | | | | | | |
| March | | | | | 880 | | | | | | | |
| June 13 West | 16 | | | | 530 | | | | | | | |
| 24 | 18 | | | | 546 | | | | | | | |
| July 1 Southeast | 20.5 | | 46 | | 537 | | | | | | | |

## Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 8, 1969 | | | | | | | | | | | | |
| Southeast | 21.5 | | 50 | | 528 | | | | | | | |
| 15 | | | | | | | | | | | | |
| West | 29 | | 42 | | 516 | | | | | | | |
| Center | 27.5 | | 48 | | 520 | | | | | | | |
| Southeast | 27.0 | | 75 | | 516 | | | | | | | |
| 22 | | | | | | | | | | | | |
| West | 25.5 | | 47 | | 526 | | | | | | | |
| Center | 25 | | 47 | | 524 | | | | | | | |
| Southeast | 25.5 | | 50 | | 528 | | | | | | | |
| 29 | | | | | | | | | | | | |
| West | 24.4 | | 75 | | 539 | | | | | | | 10.8 |
| Center | 24 | | 87 | | 540 | | | | | | | 11.0 |
| Southeast | 24.5 | | 97 | | 538 | | | | | | | 5.0 |
| Aug. 5 | | | | | | | | | | | | |
| West | 25.0 | | 75 | | 537 | | | | | | | 20.0 |
| Center | 24.5 | | 65 | | 532 | | | | | | | 21.8 |
| Southeast | 24.5 | | 95 | | 534 | | | | | | | 18.3 |

## Appendix A. Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 14, 1969 | | | | | | | | | | | | |
| West | 24 | | 45 | | 554 | | | | | | | 22.5 |
| Center | 24 | | 49 | | 547 | | | | | | | |
| Southeast | 24.5 | | 78 | | 549 | | | | | | | 21.0 |
| 20 | | | | | | | | | | | | |
| West | 22.8 | 10 | 50 | | 547 | | | | | | | 20.0 |
| Center | 23.0 | 13 | 55 | | 546 | | | | | | | 20.7 |
| Southeast | 23.5 | 14 | 66 | | 550 | | | | | | | 20.4 |
| 26 | | | | | | | | | | | | |
| West | 24 | | 44 | | 520 | | | | | | | 19.0 |
| Center | 24 | | 68 | | 546 | | | | | | | 17.8 |
| Southeast | 23 | | 95 | | 554 | | | | | | | 17.3 |
| Sept. 12 | | | | | | | | | | | | |
| West | 21 | 9 | 25 | | 550 | | | | | | | |
| Center | 21 | 13 | 61 | | 552 | | | | | | | |
| Southeast | 21 | 13 | 80 | | 576 | | | | | | | |
| 27 | | | | | | | | | | | | |
| West | 16 | 10 | 50 | | 565 | | | | | | | 25.2 |
| Center | 16 | 12 | 57 | | 557 | | | | | | | 19.9 |
| Southeast | 17 | 13 | 83 | | 557 | | | | | | | 24.6 |

Appendix Results of Chemical Analyses of Lake Madison

| Date | Temperature °C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 14, 1969 | | | | | | | | | | | | |
| West | 8 | 10 | 70 | | 575 | | | | | | | 17.9 |
| Center | 8 | 10 | 71 | | 573 | | | | | | | 20.4 |
| Southeast | 8 | 10 | 64 | | 575 | | | | | | | 19.6 |
| 26 | | | | | | | | | | | | |
| West | 5 | 10 | 72 | | 593 | | | | | | | |
| Center | 5 | 10 | 80 | | 581 | | | | | | | |
| Southeast | 5 | 13 | 81 | | 577 | | | | | | | |
| Nov. 9 | | | | | | | | | | | | |
| West | 7 | 9 | 72 | | 491 | | | | | | | 17.3 |
| Center | 7 | 12 | [illegible] | | 593 | | | | | | | 17.7 |
| Southeast | 7 | 12 | 160 | | 585 | | | | | | | 19.6 |
| Dec. 14 | | | | | | | | | | | | |
| West | 2 | 9 | 92 | | 666 | | | | | | | 19.6 |
| Center | 2 | 12 | | | 631 | | | | | | | 21.5 |
| Southeast | 2 | 12 | | | 636 | | | | | | | 21.6 |
| Jan. 4, 1970 | | | | | | | | | | | | |
| West | 0 | 12 | 36 | | 692 | | | | | | | |

Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature o C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 14, 1970 | | | | | | | | | | | | |
| West | 0.0 | 9 | 186 | | 691 | | | | | | | |
| Center | 0.0 | 12 | 254 | | 671 | | | | | | | |
| Southeast | 0.0 | 6 | 183 | | 653 | | | | | | | |
| 27 | | | | | | | | | | | | |
| West | 0.0 | 8 | 198 | | 707 | 111 | 0.02 | 0.10 | 102.7 | 0.65 | 126 | 27.8 |
| Center | | 8 | | | 688 | 105 | 0.01 | 0.11 | 96.8 | 1.31 | 116 | 25.9 |
| Southeast | | 2 | 61 | | 666 | 105 | 0.01 | 0.05 | 97.4 | 0.71 | 114 | 26.7 |
| Feb. 14 | | | | | | | | | | | | |
| West | | 8 | | | 742 | 100 | 0.01 | 0.044 | 195 | 1.42 | 130 | 24.4 |
| Center | | 10 | | | 709 | 95 | 0.01 | 0.073 | 196 | 0.27 | 135 | 25.4 |
| Southeast | | 9 | | | 749 | 95 | 0.01 | 0.118 | 191 | 1.07 | 139 | 26.0 |
| March 14 | | | | | | | | | | | | |
| West | | | | 28 | 246.4 | 65.3 | 0.01 | 0.044 | 67.6 | 0.68 | 51.5 | 15.3 |
| Center | | | | 28 | 304.0 | 64.8 | 0.01 | 0.078 | 57.5 | 0.59 | 51.5 | 14.8 |
| Southeast | | | | 18 | 461.0 | 84.0 | 0.01 | 0.051 | 125 | 1.13 | 89.4 | 18.7 |
| April 24 | | | | | | | | | | | | |
| West | | | | 25 | 516 | 91.5 | 0.00 | 0.05 | 5.9 | 0.32 | | |
| Center | | | | 23 | 545 | 88.8 | 0.00 | 0.05 | 50.4 | 0.40 | | |
| Southeast | | | | 21 | 539 | 89.2 | 0.00 | 0.05 | 51.0 | 0.45 | | |

Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 8, 1970 | | | | | | | | | | | | |
| West | 5 | 14 | 55 | 16 | 545 | 91.9 | 0.00 | 0.02 | 48.7 | 0.07 | | |
| Center | 5 | 18 | 75 | 16 | 565 | 87.9 | 0.00 | 0.02 | 50.7 | 0.11 | | |
| Southeast | 5 | 12 | 69 | 16 | 565 | 88.4 | 0.01 | 0.02 | 51.6 | 0.10 | | |
| 28 | | | | | | | | | | | | |
| West | 18.5 | 11 | 183 | 17 | 602 | 97.4 | 0.00 | 0.05 | 50.0 | 0.34 | | |
| Center | 18.5 | 14 | | 14 | 568 | 98.4 | 0.01 | 0.07 | 50.4 | 0.42 | | |
| June 5 | | | | | | | | | | | | |
| West | 21 | 10 | 310 | 15 | 625 | 104 | 0.00 | 0.06 | 50.7 | 0.49 | | |
| Center | 21.5 | 10 | 305 | 15 | 605 | 103 | 0.00 | 0.04 | 50.7 | 0.46 | | |
| Southeast | 22 | 14 | 420 | 14 | 566 | 98.8 | 0.00 | 0.04 | 50.8 | 0.37 | | |
| 11 | | | | | | | | | | | | |
| West | 23 | 12 | 190 | 12 | 602 | 111 | 0.00 | 0.06 | 80.2 | 0.21 | 103 | 22.4 |
| Center | 23 | 14 | 180 | 12 | 573 | 106 | 0.00 | 0.05 | 80.2 | 0.17 | 101 | 22.0 |
| Southeast | 23 | 16 | 235 | 12 | 599 | 105 | 0.00 | 0.05 | 79.5 | 0.32 | 99 | 21.6 |
| 18 | | | | | | | | | | | | |
| West | 23 | 12 | 118 | | 599 | 112 | 0.00 | 0.05 | 78.9 | 0.09 | 105 | 22.2 |
| Center | 22.5 | 15 | 126 | | 579 | 105 | 0.00 | 0.04 | 78.2 | 0.06 | 103 | 22.6 |
| Southeast | 23 | 16 | 164 | | 560 | 104 | 0.00 | 0.04 | 78.9 | 0.08 | 103 | 22.4 |

Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature °C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 1, 1970 | | | | | | | | | | | | |
| West | 25.8 | 15 | 80 | 28.4 | 612 | 119 | 0.00 | 0.04 | 82.1 | 0.04 | 102 | 22.8 |
| Center | 25.5 | 14 | 115 | 28.1 | 599 | 112 | 0.00 | 0.03 | 83.5 | 0.02 | 103 | 23.0 |
| Southeast | 25.5 | 14 | 137 | 26.5 | 599 | 112 | 0.00 | 0.03 | 82.8 | 0.02 | 100 | 23.0 |
| 7 | | | | | | | | | | | | |
| West | 24 | 14 | 75 | 25.3 | 622 | 110 | 0.00 | 0.02 | 84.8 | 0.03 | 103 | 23.0 |
| Center | 24.5 | 14 | 92 | 21.3 | 595 | 115 | 0.01 | 0.02 | 84.8 | 0.12 | 106 | 23.0 |
| Southeast | 23.7 | 10 | 63 | 23.7 | 593 | 110 | 0.01 | 0.03 | 83.5 | 0.03 | 106 | 23.7 |
| 14 | | | | | | | | | | | | |
| West | 26 | 10 | 65 | 23.0 | 605 | 118 | 0.00 | 0.02 | 76.2 | 0.20 | 106 | 23.5 |
| Center | 26 | 12 | 78 | 21.4 | 638 | 110 | 0.00 | 0.02 | 73.6 | 0.10 | 104 | 23.4 |
| Southeast | 26 | 13 | 102 | 20.6 | 618 | 106 | 0.00 | 0.02 | 72.3 | 0.13 | 103 | 23.2 |
| 21 | | | | | | | | | | | | |
| West | 22.5 | 10 | 54 | 29.6 | 635 | 115 | 0.01 | 0.07 | 65.2 | 0.09 | 108 | 23.4 |
| Center | 23 | 14 | 60 | 23.0 | 620 | 112 | 0.01 | 0.06 | 64.6 | 0.04 | 106 | 23.2 |
| Southeast | 22 | 14 | 65 | 31.3 | 613 | 111 | 0.01 | 0.07 | 65.2 | 0.03 | 105 | 23.2 |
| 28 | | | | | | | | | | | | |
| West | | 15 | 65 | 26.7 | 622 | 114 | 0.01 | 0.04 | 62.1 | 0.01 | 108 | 23.6 |
| Center | | 14 | 83 | 25.9 | 612 | 111 | 0.00 | 0.02 | 60.1 | 0.02 | 109 | 23.8 |
| Southeast | | 14 | 70 | 25.9 | 625 | 109 | 0.01 | 0.07 | 60.1 | 0.12 | 107 | 23.2 |

## Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 4, 1970 | | | | | | | | | | | | |
| West | 24 | 10 | 50 | 36.7 | 651 | 114 | 0.01 | 0.02 | 56.3 | 0.12 | 109 | 23.0 |
| Center | 24 | 13 | 75 | 29.9 | 625 | 113 | 0.01 | 0.02 | 56.3 | 0.12 | 112 | 24.0 |
| Southeast | 23 | 14 | 80 | 27.8 | 632 | 110 | 0.01 | 0.04 | 57.0 | 0.11 | 108 | 23.6 |
| 11 | | | | | | | | | | | | |
| West | 25.5 | 9 | 30 | 18.7 | 658 | 122 | 0.00 | 0.04 | 74.0 | 0.02 | 107 | 22.9 |
| Center | 25 | 13 | 70 | 17.1 | 655 | 116 | 0.01 | 0.03 | 73.4 | 0.02 | 109 | 23.5 |
| Southeast | 24.5 | 13 | 80 | 15.2 | 638 | 117 | 0.01 | 0.04 | 74.5 | 0.05 | 107 | 23.0 |
| 18 | | | | | | | | | | | | |
| West | 24 | 9 | 50 | 24.4 | 641 | 118 | 0.01 | 0.04 | 77.5 | 0.05 | 110 | 23.5 |
| Center | 24 | 13 | 50 | 24.4 | 636 | 118 | 0.01 | 0.04 | 76.3 | 0.05 | 111 | 23.9 |
| Southeast | 23 | 13 | 89 | 17.3 | 627 | 120 | 0.01 | 0.03 | 75.1 | 0.05 | 93 | 23.1 |
| Sept. 3 | | | | | | | | | | | | |
| West | | 10 | | 13.1 | 656 | 121 | 0.00 | 0.03 | 47.4 | 0.12 | 115 | 23.2 |
| Center | | 10 | | 12.5 | 646 | 120 | 0.00 | 0.02 | 47.4 | 0.04 | 116 | 23.4 |
| Southeast | | 13 | | 11.9 | 641 | 119 | 0.00 | 0.04 | 47.4 | 0.05 | 112 | 23.1 |
| 22 | | | | | | | | | | | | |
| West | 17 | 10 | 114 | 15.3 | 671 | 127 | 0.00 | 0.04 | 50.6 | 0.02 | 119 | 23.6 |
| Center | 17 | 12 | 120 | 15.3 | 666 | 124 | 0.00 | 0.02 | 51.2 | 0.01 | 120 | 24.2 |
| Southeast | 16 | 13 | 125 | 18.3 | 696 | 125 | 0.00 | 0.04 | 49.0 | 0.02 | 117 | 23.8 |

Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 6, 1970 | | | | | | | | | | | | |
| West | 15 | 9 | 91 | 11.9 | 686 | 130 | 0.01 | 0.03 | 81.6 | 0.05 | 125 | 24.2 |
| Center | 15 | 12 | 108 | 14.1 | 681 | 129 | 0.00 | 0.02 | 80.5 | 0.02 | 121 | 23.7 |
| Southeast | 15 | 13 | 183 | 10.8 | 691 | 126 | 0.00 | 0.03 | 80.5 | 0.02 | 122 | 24.2 |
| 21 | | | | | | | | | | | | |
| West | 10 | 10 | 153 | 18.8 | 696 | 131 | 0.01 | 0.02 | 78.6 | 0.03 | 123 | 24.2 |
| Center | 9.5 | 12 | 143 | 17.3 | 686 | 131 | 0.00 | 0.02 | 79.2 | 0.03 | 121 | 22.9 |
| Southeast | 9.5 | 13 | 202 | 14.1 | 671 | 160 | 0.00 | 0.04 | 81.6 | 0.03 | 121 | 24.2 |
| Nov. 3 | | | | | | | | | | | | |
| West | 4 | 9 | 176 | 14.2 | 691 | 129 | 0.00 | 0.04 | 89.5 | 0.05 | 122 | 23.4 |
| Center | 4 | 13 | | 14.2 | 678 | 128 | 0.01 | 0.03 | 82.3 | 0.02 | 121 | 22.8 |
| Southeast | 4 | | | 14.2 | 691 | 128 | 0.01 | 0.02 | 77.3 | 0.01 | 123 | 22.9 |
| Dec.19 | | | | | | | | | | | | |
| West | 0.0 | 8.5 | 152 | 17.9 | 682 | 144 | | 0.02 | 98.6 | 0.02 | 129.2 | 27.4 |
| Center | 0.0 | 5 | 91 | 18.9 | 776 | 144 | 0.01 | 0.03 | 99.7 | 0.02 | 128.6 | 27.7 |
| Southeast | 0.0 | 9 | | 18.9 | 632 | 124 | | 0.02 | 84.1 | 0.04 | 113.2 | 23.9 |
| Jan. 19, 1971 | | | | | | | | | | | | |
| West | 0.0 | 8 | | 21.9 | 854 | 162 | 0.01 | 0.02 | 111.9 | 0.11 | 143.1 | 30.1 |
| Center | 0.0 | 10 | | 18.3 | 829 | 156 | 0.01 | | 108.7 | 0.10 | 134.5 | 29.7 |
| Southeast | 0.0 | 9 | | 18.5 | 799 | 148 | 0.01 | 0.01 | 105.5 | 0.11 | 132.3 | 27.6 |

## Appendix A Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. 12, 1971 | | | | | | | | | | | | |
| West | 0 | 8.5 | | 22.0 | 868 | 166 | 0.01 | 0.03 | 108.7 | 0.30 | 151.4 | 28.2 |
| Center | 0 | 7 | | 20.5 | 819 | 153 | 0.01 | 0.02 | 107.1 | 0.17 | 138.8 | 28.1 |
| Southeast | 0 | 8 | | 21.8 | 829 | 150 | 0.01 | 0.02 | 105.9 | 0.22 | 134.8 | 27.1 |
| March 5 | | | | | | | | | | | | |
| West | 0 | | | 25.9 | 737 | 148.8 | 0.01 | 0.11 | 87.6 | 0.61 | 147.2 | 24.3 |
| Center | 0 | | | 21.8 | 771 | 147.0 | 0.01 | 0.02 | 101.7 | 0.16 | 130.3 | 28.0 |
| Southeast | 0 | | | 20.6 | 796 | 152.0 | 0.01 | 0.03 | 107.2 | 0.23 | 139.5 | 26.8 |
| April 12 | | | | | | | | | | | | |
| West | 7 | 10 | 77 | 23.1 | 617 | 116.6 | 0.01 | 0.03 | 78.7 | 0.15 | 106.6 | 22.2 |
| Center | 6 | 14 | 82 | 21.2 | 627 | 117.8 | 0.02 | 0.02 | 82.3 | 0.05 | 110.9 | 21.6 |
| Southeast | 6.5 | 14 | 102 | 21.2 | 622 | 117.8 | | 0.02 | 82.3 | 0.18 | 109.6 | 22.0 |
| April 30 | | | | | | | | | | | | |
| West | 11.5 | 11 | 150 | 20.6 | 622 | 118.2 | | 0.03 | 79.4 | 0.05 | 106.2 | 21.6 |
| Center | 11 | 14 | 310 | 18.3 | 623 | 118.6 | 0.01 | 0.02 | 83.0 | 0.03 | 110.3 | 22.0 |
| Southeast | 11 | 14 | 320 | 18.7 | 665 | 118.6 | 0.01 | 0.01 | 83.0 | 0.06 | 110.3 | 21.6 |
| May 12 | | | | | | | | | | | | |
| West | 15 | 10 | 260 | 20.5 | 632 | 96.1 | 0.01 | 0.02 | 66.8 | 0.10 | 88.2 | 18.8 |
| Center | 15 | 13 | 261 | 21.2 | 635 | 111.6 | 0.01 | 0.02 | 75.9 | 0.02 | 102.6 | 20.4 |
| Southeast | 15 | 14 | 283 | 20.0 | 650 | 100.8 | 0.01 | 0.02 | 73.2 | 0.06 | 97.8 | 18.6 |

Appendix A  Results of Chemical Analyses of Lake Madison

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 27, 1971 | | | | | | | | | | | | |
| West | 15 | 10 | 305 | 20.1 | 653 | 118.6 | | 0.02 | 83.7 | 0.04 | 112.3 | 22.7 |
| Center | 15 | 10 | 305 | 19.6 | 633 | 119.0 | | 0.01 | 85.1 | 0.04 | 113.0 | 22.2 |
| Southeast | 15.5 | 14 | 427 | 18.5 | 633 | 119.4 | | 0.02 | 85.8 | 0.02 | 113.0 | 22.6 |

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | pH | Alkalinity mg $CaCO_3/1$ | Dissolved Oxygen mg $O_2/1$ | COD mg/1 | Conductivity ppm NaCl | Chloride mg Cl/1 | Silica mg $SiO_2/1$ | Ortho Phosphate mg $PO_4/1$ | Total Phosphorus mg $PO_4/1$ | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_2$-N/1 | Nitrite $\mu$g $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 23, 1968 | | | | | | | | | | | | |
| Bourne's Slough | | | 13.7 | | | | | | | | | |
| 24 | | | | | | | | | | | | |
| Silver Creek at Bourne's Slough | | | 4.2 | | | | | | | | | |
| Bourne's Slough | | | 9.65 | | | | | | | | | |
| 29 | | | | | | | | | | | | |
| Silver Creek at Lagoon | | 165 | | | | | | | 6.40 | | | |
| Bourne's Slough | | 144 | | | | | | | 0.68 | | | |
| December | | | | | | | | | | | | |
| Treated Sewage | | | | | | | | | 36.2 | 1.80 | 0.25* | |
| Lagoon | | | | | | | | | 28.6 | 2.65 | 0.45 | |
| April 9, 1969 | | | | | | | | | | | | |
| Silver Creek above Lagoon | 7.8 | 54.6 | | | | | | | 1.2 | 0.23 | 1.0 | |
| Silver Creek at Lagoon | 7.4 | 72.7 | | | | | | | 2.0 | 0.44 | 1.55 | |

*Nitrates from December, 1968, through August 27, 1969, are actually nitrate plus nitrite determined according to the procedure on Page 41 of the Hach Manual.

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | pH | Alkalinity mg CaCO$_3$/l | Dissolved Oxygen mg O$_2$/l | COD mg/l | Conductivity ppm NaCl | Chloride mg Cl/l | Silica mg SiO$_2$/l | Ortho Phosphate mg PO$_4$/l | Total Phosphorus mg PO$_4$/l | Ammonia mg NH$_3$-N/l | Nitrate mg NO$_3$-N/l | Nitrite µg NO$_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| August 27, 1969 | | | | | | | | | | | | |
| Treated Sewage | 7.1 | [illegible] | | | 1800 | 518 | | | | | 0.75 | |
| Silver Creek above Lagoon | 8.0 | [illegible] | | | 1200 | 123 | | | 0.16 | | 0.070 | |
| Silver Creek at Lagoon | 8.2 | [illegible] | | | 1700 | 504 | | | 5.4 | | 0.310 | |
| Bourne's Slough | 9.2 | [illegible] | 9.13 | | | 172 | | | 1.95 | | | |
| September [illegible] | | | | | | | | | | | | |
| Silver Creek at Bourne's Slough | 8.05 | [illegible] | [illegible] | | [illegible] | [illegible] | | | 0.82 | 1.05 | 0.19* | 56.4 |
| Bourne's Slough | [illegible] | [illegible] | 11.0 | | [illegible] | 156 | | | .54 | [illegible] | 0.64 | 15.5 |
| February 1[illegible], 14, 1970 | | | | | | | | | | | | |
| Treated Sewage | [illegible] | [illegible] | [illegible] | | [illegible]**873 | [illegible] | 24.[illegible] | 19.8 | 18.6 | [illegible] | | [illegible] |
| Lagoon | 8.39 | [illegible] | | | [illegible] | [illegible] | 29.1 | 22.2 | 28.8 | 17.95 | | [illegible] |
| Silver Creek at Lagoon | [illegible] | 305 | | | [illegible] | 739 | 27.51 | 21.9 | 30.6 | [illegible] | | 18.1 |
| Silver Creek between Lagoon and Slough | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | 73.5 | 28.8 | 44.1 | 19.75 | | 10.8 |
| Bourne's Slough | 7.16 | [illegible] | | | [illegible] | [illegible] | 11.1 | 1.14 | [illegible] | .47 | | 7.6 |

*Beginning with this sample nitrates were determined according to the FWPCA Manual method.

**Starting with this sample, all further conductivities were determined according to the procedure in the FWPCA manual and are expressed in µmhos/cm at 25° C.

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | pH | Alkalinity mg CaCO$_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite µg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| March 21, 1970 | | | | | | | | | | | | |
| Treated Sewage | 6.91 | 202 | 2.38 | | [illegible]87 | 827 | 19.92 | 14.26 | 15.19 | 14.30 | 0.770 | 299.9 |
| Silver Creek above Lagoon | 7.48 | 231 | 15.35 | | 2100 | 172 | 9.30 | 0.14 | 0.29 | 0.97 | 0.239 | 24.3 |
| Silver Creek at Lagoon | 7.18 | 22[illegible] | [illegible].42 | | 4120 | 481 | 16.46 | 12.09 | 12.65 | 19.24 | 0.020 | 62.4 |
| April 4 | | | | | | | | | | | | |
| Silver Creek at Memorial Creek | 7.53 | 70.[illegible] | 11.6 | 50.5 | | 73.6 | 7.39 | 0.92 | 1.49 | 0.55 | 1.17 | 74.8 |
| Silver Creek below City Dump | 7.49 | 86.[illegible] | 11.2 | 56.9 | | 41.4 | 8.26 | 0.84 | 1.20 | 0.79 | 0.78 | 77.2 |
| Silver Creek at Lagoon | 7.20 | 165 | 5.9 | 58.3 | | 306 | 14.5 | 10.44 | | 13 | 0.23 | 47.2 |
| Silver Creek Between Lagoon and Slough | 7.77 | 91.[illegible] | 12.0 | 55.9 | | 20.2 | 8.02 | 0.98 | 1.53 | 0.98 | 1.87 | 68.2 |
| Silver Creek at Bourne's Slough | 7.54 | 98.[illegible] | 12.25 | | | 40.9 | 9.0 | 1.37 | 1.87 | 1.64 | 0.49 | 54.9 |
| Bourne's Slough | 7.20 | 95.[illegible] | 7.85 | | | 77.5 | 8.8 | 1.62 | 1.74 | 1.96 | 0.58 | 52.8 |
| Tributary East of Lake Madison Resort | 7.40 | 63.[illegible] | 10.6 | 106 | | 5.1 | 9.51 | 0.62 | 2.36 | 0.67 | 2 | 92.6 |
| Tributary North of Johnson's Point | 7.13 | 56.4 | 9.8 | 52.1 | | 7.4 | 7.69 | 0.74 | 1.32 | 0.75 | 0.95 | 105.4 |
| Tributary West of Wentworth Park | 7.38 | 60.[illegible] | 10.1 | | | 4.1 | 9.1 | 0.83 | 2.07 | 0.45 | 0.99 | 111.6 |

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 4, 1970 | | | | | | | | | | | | |
| Tributary North of Fischer's Point | 7.72 | 53.0 | 10.85 | | | 3.8 | 9.0 | 0.98 | 3.90 | 0.34 | 0.62 | 84.7 |
| 23 | | | | | | | | | | | | |
| Bourne's Slough | 7.91 | 156 | 12.85 | | | 56.8 | 9.97 | 0.96 | 1.17 | 0.96 | 0.67 | 26.6 |
| Madison Outlet Creek | 8.90 | 150 | 15.7 | | | 123 | 0.70 | 0.24 | 1.04 | 0.26 | | 5.6 |
| June 5 | | | | | | | | | | | | |
| Bourne's Slough | 7.38 | 199 | 2.5 | 28.6 | 1760 | 155 | 14.4 | 0.88 | 1.18 | | 0.07 | 19.4 |
| 11 | | | | | | | | | | | | |
| Silver Creek at Bourne's Slough | 8.10 | 239 | | 40.7 | 2290 | 311 | 22.1 | 3.28 | 5.37 | | 0.82 | 85.3 |
| July 14 | | | | | | | | | | | | |
| Silver Creek above Lagoon | 7.70 | 256 | | | 1719 | 140 | 21.6 | 0.34 | 0.43 | 0.46 | 0.118 | 11.57 |
| Lagoon | 8.53 | 152 | | | 2617 | 529 | 24.0 | 3.49 | 6.11 | 3.85 | 0.408 | 131 |
| Silver Creek below Lagoon | 8.45 | 173 | | | 2430 | 419 | 22.3 | 2.75 | 4.65 | 3.13 | 0.408 | 133 |
| Bourne's Slough | 7.56 | 188 | | | 1495 | 225 | 27.2 | 2.26 | 2.74 | 2.81 | 0.009 | 28.95 |

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 28, 1970 | | | | | | | | | | | | |
| Silver Creek below Lagoon | 9.90 | 129 | 8.0 | | 2542 | 540 | 8.1 | 0.10 | 0.41 | 0.14 | | 18.63 |
| Silver Creek at Bourne's Slough | 7.90 | 157 | 0.8 | | 2969 | 570 | 22.2 | 3.52 | 8.07 | | 0.00 | 7.13 |
| Bourne's Slough | 8.51 | 168 | 9.8 | | 1648 | 147 | 26.9 | 0.34 | 0.93 | 0.07 | 0.00 | 1.23 |
| August 26 | | | | | | | | | | | | |
| Treated Sewage | 6.55 | 171 | 3.6 | 51.4 | 2845 | 485 | 50.8 | 23.00 | 28.41 | 5.95 | 2.94 | 255 |
| Silver Creek at Lagoon | 7.43 | 188 | 5.4 | 81.9 | 3129 | 568 | 47.5 | 15.42 | 18.28 | 8.51 | 0.314 | 205 |
| Silver Creek between Lagoon and Slough | 7.88 | 179 | 11.65 | 66.6 | 3129 | 558 | 47.5 | 4.86 | 15.64 | 8.28 | 0.343 | 342 |
| Silver Creek at Bourne's Slough | 7.32 | 221 | | 62.8 | 1753 | 583 | 31.8 | 6.13 | 10.55 | 6.86 | 0.179 | 144 |
| Bourne's Slough | 8.23 | 174 | 9.1 | 54.1 | 1609 | 273 | 37.5 | 0.57 | 0.93 | 0.12 | 0.010 | 4.74 |
| October 6 | | | | | | | | | | | | |
| Bourne's Slough | 8.78 | 187 | 7.8 | 75.7 | 2036 | 209 | 5.24 | 0.088 | 1.06 | 0.01 | 0.008 | 0.95 |
| January 19, 1971 | | | | | | | | | | | | |
| Silver Creek at Lagoon | 7.13 | 499 | 0.0 | 19.3 | 2855 | 439 | 42.1 | 6.20 | 11.07 | 2.45 | 0.04 | 3.84 |

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | pH | Alkalinity mg $CaCO_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite µg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February 17, 1971 | | | | | | | | | | | | |
| Silver Creek at Memorial Creek | 7.57 | 58.9 | 11.6 | 89.9 | 192 | 23.8 | 2.7 | 1.44 | 3.33 | 0.80 | 0.830 | 63.8 |
| Silver Creek below City Dump | 7.07 | 54.8 | 11.4 | 76.7 | 535 | 106 | 2.6 | 1.38 | 2.87 | 0.49 | 1.120 | 72.3 |
| Silver Creek below Lagoon | 7.38 | 49.7 | 11.6 | 43.0 | 383 | 23.2 | 0 | 1.83 | 2.89 | 0.51 | 0.885 | 39.9 |
| March 5 | | | | | | | | | | | | |
| Bourne's Slough | 7.13 | 81.2 | 7.6 | 42.7 | 465 | 38.7 | 3.9 | 1.01 | 1.52 | 0.80 | 0.425 | 59.0 |

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | Temperature $^{o}$C. | Depth of Water (feet) | Filtered Solids (g/1) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 30, 1968 | | | | | | | | | | | | |
| Silver Creek at Lagoon | | | | | 976 | | | | | | | |
| Bourne's Slough | | | | | 741 | | | | | | | |
| April 9, 1969 | | | | | | | | | | | | |
| Silver Creek above Lagoon | | | | | 114 | | | | | | | |
| Silver Creek at Lagoon | | | | | 122 | | | | | | | |
| August 27 | | | | | | | | | | | | |
| Treated Sewage | | | | | 978 | | | | | | | |
| Silver Creek above Lagoon | | | | | 1386 | | | | | | | 15.5 |
| Silver Creek at Lagoon | | | | | 942 | | | | | | | 20.0 |
| Bourne's Slough | | | | | 626 | | | | | | | 19.8 |
| September 27 | | | | | | | | | | | | |
| Silver Creek at Bourne's Slough | | 8 | | | 632 | | 2.2 | | | | | 21.7 |
| Bourne's Slough | | 3.5 | | | 593 | | 1.0 | | | | | 22.2 |

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | Temperature °C. | Depth of Water (feet) | Filtered Solids (g/l) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February 13, 14, 1970 | | | | | | | | | | | | |
| Treated Sewage | | | | | 1287 | 480 | 0.02 | 0.142 | 264 | 0.41 | 522 | 29.8 |
| Lagoon | | | | | 1287 | 490 | 0.02 | 0.103 | 249 | 0.67 | 498 | 34.2 |
| Silver Creek at Lagoon | | | | | 1217 | 288 | 0.01 | 0.147 | 257 | 0.45 | 449 | 31.8 |
| Silver Creek between Lagoon and Slough | | | | | 1952 | 457 | 0.01 | 0.097 | 394 | 14.5 | 566 | 40.2 |
| Bourne's Slough | | 3 | | | 940 | 128 | 0.00 | 0.078 | 227 | 1.60 | 146 | 28.0 |
| March 21 | | | | | | | | | | | | |
| Treated Sewage | | | 0.042 | 34 | 1068 | | | | | | | |
| Silver Creek above Lagoon | | | 0.010 | 19 | 962 | | | | | | | |
| Silver Creek at Lagoon | | | 0.158 | 30 | 894 | | | | | | | |
| April 4 | | | | | | | | | | | | |
| Silver Creek at Memorial Creek | 6 | 2 | 0.054 | 233 | 167 | 38.0 | 0.00 | 0.15 | 26.4 | 0.11 | | |
| Silver Creek below City Dump | | 3 | 0.008 | 186 | 191 | 52.8 | 0.01 | 0.25 | 39.2 | 0.29 | | |
| Silver Creek at Lagoon | | 2 | 0.036 | 215 | 756 | 138 | 0.01 | 0.08 | 45.0 | 0.46 | | |
| Silver Creek between Lagoon and Slough | | 3 | 0.050 | 196 | 222 | 55.6 | 0.00 | 0.21 | 107 | 0.28 | | |

Appendix B  Results of Chemical Analyses of Lake Madison Tributaries

| Date | Temperature °C. | Depth of Water (feet) | Filtered Solids (g/l) | Turbidity Jackson Turbidity Units | Hardness mg CaCO3/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 4, 1970 | | | | | | | | | | | | |
| Silver Creek at Bourne's Slough | | 6 | 0.024 | 196 | 261 | 64.0 | 0.00 | 0.16 | | 0.34 | | 15.4 |
| Bourne's Slough | | 4 | 0.008 | 186 | 259 | 71.9 | 0.01 | 0.23 | | 0.36 | | 15.1 |
| Tributary East of Lake Madison Resort | | 3 | 0.539 | 91 | 139 | | 0.01 | | | 0.16 | 4.8 | 8.7 |
| Tributary North of Johnson's Point | | 1 | 0.080 | 280 | 57.4 | | 0.00 | | | 0.13 | 0.5 | 9.6 |
| Tributary West of Wentworth Park | | 2 | 0.285 | 268 | 104.3 | | 0.00 | | 31.0 | 0.10 | 3.5 | 10.4 |
| Tributary North of Fischer's Point | | 2 | 2.266 | 415 | 98.6 | | 0.00 | | 10.6 | 0.04 | 1.5 | 9.5 |
| 23 | | | | | | | | | | | | |
| Bourne's Slough | | 4 | | 21 | 438 | 97.2 | 0.00 | 0.05 | 15.5 | 0.18 | | |
| Madison Outlet Creek | | 1.5 | | 19 | 561 | 91.9 | 0.00 | 0.04 | 5.6 | 0.47 | | |
| June 5 | | | | | | | | | | | | |
| Bourne's Slough | 23 | | | 15 | 652 | 134 | 0.00 | 0.09 | 49.1 | 0.65 | | |
| 11 | | | | | | | | | | | | |
| Silver Creek at Bourne's Slough | | 6 | 0.018 | 18 | 1007 | 249 | 0.00 | 0.25 | 97.5 | 0.63 | 211 | 19.3 |

Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | Temperature °C. | Depth of Water (feet) | Filtered Solids (g/l) | Turbidity (Jackson Turbidity Units) | Hardness mg CaCO /l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 14, 1970 | | | | | | | | | | | | |
| Silver Creek above Lagoon | 27 | 1 | | 17.1 | 1112 | 283 | 0.01 | 0.27 | 74.3 | 0.99 | 85 | 17.2 |
| Lagoon | 28 | $\frac{1}{2}$ | | 22.7 | 1145 | 179 | 0.01 | 0.06 | 73.6 | 0.20 | 330 | 23.0 |
| Silver Creek below Lagoon | 28 | 2 | | 21.4 | 888 | 201 | 0.01 | 0.09 | 73.6 | 0.38 | 290 | 22.2 |
| Bourne's Slough | 27 | | | 16.5 | 724 | 153 | 0.00 | 0.07 | 70.3 | 0.68 | 155 | 21.2 |
| 28 | | | | | | | | | | | | |
| Silver Creek below Lagoon | 27 | 2 | | 104 | 770 | 174 | 0.01 | 0.02 | 58.3 | 0.02 | 355 | 25.1 |
| Silver Creek at Bourne's Slough | | 6 | | 28.0 | 921 | 184 | 0.01 | 0.26 | 69.0 | 2.48 | 366 | 26.2 |
| Bourne's Slough | | 5 | | 29.8 | 651 | 117 | 0.01 | 0.03 | 60.1 | 0.03 | 115 | 23.7 |
| August 26 | | | | | | | | | | | | |
| Treated Sewage | | | | 11.4 | 987 | 193 | 0.01 | 0.09 | 72.3 | 0.34 | 315 | 23.3 |
| Silver Creek at Lagoon | | 1.5 | | 11.4 | 908 | 204 | 0.01 | 0.16 | 86.4 | 0.31 | 384 | 26.4 |
| Silver Creek between Lagoon and Slough | 27 | 1 | | 19.7 | 947 | 221 | 0.01 | 0.23 | 93.8 | 0.89 | 371 | 26.1 |
| Silver Creek at Bourne's Slough | | 6 | | 17.7 | 947 | 201 | 0.01 | 0.21 | 87.5 | 0.40 | 382 | 26.4 |
| Bourne's Slough | | 3 | | 10.4 | 651 | 181 | 0.01 | 0.05 | 75.7 | 0.19 | 121 | 24.4 |

## Appendix B Results of Chemical Analyses of Lake Madison Tributaries

| Date | Temperature $^{o}$C. | Depth of Water (feet) | Filtered Solids (g/l) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| October 6, 1970 | | | | | | | | | | | | |
| Bourne's Slough | 16 | 3 | | 24.9 | 755 | 147 | 0.00 | 0.04 | 86.9 | 0.32 | 156 | 24.4 |
| January 19, 1971 | | | | | | | | | | | | |
| Silver Creek at Lagoon | 0.0 | | | 30.9 | 1332 | | 0.01 | 0.10 | 116.7 | 10.2 | | 17.1 |
| February 17 | | | | | | | | | | | | |
| Silver Creek at Memorial Creek | 0 | 1 | 0.194 | 81 | 128 | 23.0 | 0.01 | 0.40 | 5.4 | 0.19 | 12.3 | 11.2 |
| Silver Creek below City Dump | 0 | 1 | 0.130 | 86 | 168 | 36.8 | 0.01 | 0.40 | 8.7 | 0.33 | 57.4 | 10.5 |
| Silver Creek below Lagoon | 0 | 1 | 0.018 | 34.7 | 168 | 40.5 | 0.01 | 0.12 | 13.2 | 0.23 | 13.1 | 11.7 |
| March 5 | | | | | | | | | | | | |
| Bourne's Slough | | | | 25.0 | 164 | 42.8 | | 0.33 | 16.5 | 0.43 | 23.7 | 9.9 |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity ppm NaCl | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$- N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June, 1968 | 8.49 | 210 | 8.1 | | | 6.75 | | | 0.55 | 0.32 | 0.5* | |
| July | 8.62 | 182 | 8.9 | | | 6.7 | | | 0.36 | 1.14 | 0.06 | |
| September | 8.2 | 179 | 9.2 | | | 21.5 | | | 0.37 | 0.60 | 0.08 | |
| October | 7.85 | 203 | 10.8 | | | 13.1 | | | 0.39 | 0.49 | 0.47 | |
| November | 8.2 | 196 | 8.2 | | | [illegible] | | | | 0.42 | 0.27 | |
| December | 8.3 | 219 | 6.0 | | | 15.0 | | | 0.27 | 0.54 | 0.065 | |
| January, 1969 | 8 | 272 | 1.7 | | | 15.5 | | | 0.34 | 1.56 | 0.495 | |
| February | 9.7 | 157 | 1.0 | | | 18.35 | | | 0.29 | 0.63 | 1.25 | |
| March | 7.8 | 252 | 3.9 | | | 4.95 | | | 0.33 | 0.59 | 2.75 | |
| May 6<br>Center | 7.15 | 89 | 8.86 | | 395 | 7 | | | 2.0 | 1.08 | 0.75 | |
| June 26<br>Center | 8.0 | 151 | 8.9 | | 395 | 3.2 | | | 2.0 | 0.075 | 0.44 | |

* Nitrates from June, 1968, through August 22, 1969, are actually nitrate plus nitrite and are determined according to the procedure on page 41 of the Hach Manual.

## Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3/1$ | Dissolved Oxygen mg $O_2/1$ | COD mg/1 | Conductivity ppm NaCl | Chloride mg Cl/1 | Silica mg $SiO_2/1$ | Ortho Phosphate mg $PO_4/1$ | Total Phosphorus mg $PO_4/1$ | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 3, 1969 | | | | | | | | | | | | |
| Center | 8.15 | 155 | 9.6 | | 410 | 6.00 | | | 0.75 | 0.11 | 0.35 | |
| 10 | | | | | | | | | | | | |
| Dredge | 8.3 | 161 | 9.9 | | 420 | 4.80 | | | 0.70 | 0.18 | 0.22 | |
| Center | 8.45 | 159 | 9.8 | | 425 | 4.25 | | | 0.71 | 0.15 | 0.20 | |
| 17 | | | | | | | | | | | | |
| Dredge | 7.1 | 163 | 7.3 | | 380 | 2.5 | | | 0.73 | 0.25 | 0.05 | |
| Center | 7.25 | 161 | 7.8 | | 375 | 2.5 | | | 0.78 | 0.17 | 0.09 | |
| 24 | | | | | | | | | | | | |
| Dredge | | 163 | 7.2 | | 380 | 5.21 | | | 1.08 | 0.17 | 0.015 | |
| Center | | 163 | 7.1 | | 385 | 6.09 | | | 1.06 | 0.14 | 0.01 | |
| Southeast | | 164 | 8.55 | | 380 | 4.38 | | | 1.11 | 0.16 | 0.005 | |
| 31 | | | | | | | | | | | | |
| Dredge | 8.6 | 173 | 8.25 | | 400 | 8.04 | | | 1.22 | 0.28 | 0.01 | |
| Center | 8.4 | 173 | 8.1 | | 385 | 5.84 | | | 1.07 | 0.25 | 0.01 | |
| Southeast | 8.25 | 187 | 8.9 | | 400 | 5.36 | | | 1.24 | 0.28 | 0.00 | |
| Aug. 7 | | | | | | | | | | | | |
| Dredge | 8.1 | 175 | 7.8 | | 420 | 5.06 | | | 1.36 | 0.30 | 0.115 | |
| Center | 8.15 | 172 | 8.1 | | 415 | 5.30 | | | 1.19 | 0.47 | 0.075 | |
| Southeast | 8.4 | 182 | 8.3 | | 425 | 5.06 | | | 1.21 | 0.29 | 0.11 | |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity ppm NaCl | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 15, 1969 | | | | | | | | | | | | |
| Dredge | | 171 | 8.4 | | 380 | 5.30 | | | 1.21 | 0.34 | 0.075 | |
| Center | 8.4 | 170 | 7.9 | | 395 | 5.30 | | | 1.23 | 0.31 | 0.10 | |
| Southeast | 8.4 | 180 | 10.0 | | 400 | 5.30 | | | 1.22 | 0.43 | 0.053 | |
| 22 | | | | | | | | | | | | |
| Dredge | 8.25 | 172 | 7.40 | | 375 | 4.3 | | | 1.06 | 1.57 | 0.032 | |
| Center | 7.75 | 172 | 7.95 | | 325 | 4.6 | | | 1.04 | 2.13 | 0.020 | |
| Southeast | 8.3 | 178 | 9.50 | | 360 | 4.1 | | | 1.10 | 1.67 | 0.068 | |
| 28 | | | | | | | | | | | | |
| Dredge | 8.25 | 174 | 8.1 | | 440 | 5.54 | | | 1.10 | 1.48 | 0.050* | |
| Center | 8.25 | 174 | 8.0 | | 400 | 5.06 | | | 1.25 | | 0.00 | |
| Southeast | 8.50 | 178 | 9.2 | | 405 | 4.58 | | | 1.38 | 2.51 | 0.00 | |
| Sept. 4 | | | | | | | | | | | | |
| Dredge | 8.2 | 179 | 7.6 | | 400 | 6.99 | | | 0.94 | 2.51 | trace | |
| Center | 8.25 | 176 | 7.8 | | 400 | 6.75 | | | 0.97 | 0.81 | trace | |
| Southeast | 8.4 | 180 | 8.1 | | 402 | 6.75 | | | 1.03 | 0.81 | 0.00 | |
| 17 | | | | | | | | | | | | |
| Dredge | 8.15 | 180 | 8.5 | | | | | | 1.09 | 0.49 | 0.13 | |
| Center | 8.0 | 181 | 8.1 | | 300 | | | | 1.06 | 0.50 | 0.13 | |
| Southeast | 8.4 | 187 | 10.3 | | 350 | | | | 1.12 | 0.50 | 0.00 | |

*Beginning with this sample all nitrates were determined according to the FWPCA Manual method.

## Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity ppm NaCl | Chloride mg Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite µg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 4, 1969 | | | | | | | | | | | | |
| Dredge | 8.3 | 183 | 8.3 | | 389 | 4.82 | | | 0.93 | | 0.000 | 4.84 |
| Center | 8.3 | 182 | 8.2 | | 400 | 4.58 | | | 0.83 | | 0.023 | 6.67 |
| Southeast | 8.6 | 189 | 7.9 | | 450 | 5.06 | | | 1.02 | | 0.16 | 6.00 |
| 19 | | | | | | | | | | | | |
| Dredge | 8.4 | 179 | 11.95 | | 867* | 3.86 | | 0.58 | 0.84 | | 0.012 | 5.82 |
| Center | 8.4 | 179 | 11.6 | | 423 | 3.86 | | 0.62 | 0.77 | | 0.024 | 5.84 |
| Southeast | 8.5 | 189 | 12.6 | | 430 | 3.62 | | 0.50 | 0.70 | | 0.015 | 4.22 |
| Nov. 3 | | | | | | | | | | | | |
| Dredge | 8.35 | 177 | 13.0 | | 887* | 3.80 | | 0.53 | 0.70 | 0.29 | 0.04 | 6.2 |
| Center | 8.35 | 176 | 13.5 | | 900 | 3.62 | | 0.53 | 0.65 | 0.25 | 0.12 | 4.6 |
| Southeast | 8.35 | 178 | 13.3 | | 900 | 3.38 | | 0.39 | 0.65 | 0.26 | 0.10 | 7.1 |
| North | 8.35 | 178 | 13.6 | | 900 | 3.38 | | 0.56 | 0.72 | 0.33 | 0.04 | 7.6 |
| Dec. 21 | | | | | | | | | | | | |
| Dredge | 8.1 | 187 | 11.6 | | 990 | 4.17 | | 0.42 | 0.62 | 0.14 | 0.070 | 3.21 |
| Center | 8.12 | 188 | 11.8 | | 1000 | 4.41 | | 0.42 | 0.65 | 0.35 | 0.035 | 1.09 |
| Jan. 4, 1970 | | | | | | | | | | | | |
| North | 8.15 | 199 | 10.8 | | 1030 | 5.3 | 13.6 | 0.42 | 0.63 | 0.26 | 0.00 | 5.9 |
| Southeast | 8.15 | 215 | 8.8 | | 1090 | 4.3 | 14.0 | 0.43 | 0.66 | 0.17 | 0.11 | 9.9 |

*Starting with these samples, all further conductivities were determined according to the procedure in the FWPCA Manual and are expressed in µmhos/cm at 25° C.

Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 23, 1970 | | | | | | | | | | | | |
| North | 7.60 | 235 | 5.15 | | 1220 | 7.2 | 11.5 | 0.52 | 0.74 | 1.36 | 0.00 | 4.72 |
| Dredge | 7.52 | 202 | 4.2 | | 1080 | 7.0 | 7.2 | 0.48 | 0.55 | 1.05 | 0.10 | 9.10 |
| Center | 7.54 | 202 | | | 1080 | 6.7 | 7.2 | 0.46 | 0.57 | 0.77 | 0.10 | 4.40 |
| Southeast | 7.60 | 220 | | | 1140 | 6.5 | 7.8 | 0.59 | 0.68 | 0.88 | 0.02 | 3.33 |
| Feb. 6, 7 | | | | | | | | | | | | |
| North | 7.53 | 230 | 7.0 | | 1160 | 7.7 | 23.7 | 0.52 | 0.72 | 0.26 | 0.07 | 10.6 |
| Dredge | 7.40 | 214 | 2.7 | | 1120 | 7.2 | 23.4 | 0.48 | 0.59 | 0.43 | 0.05 | 9.71 |
| Center | 7.50 | 217 | 6.5 | | 1110 | 7.7 | 23.0 | 0.52 | 0.63 | 0.43 | 0.00 | 8.94 |
| Southeast | 7.30 | 234 | 2.3 | | 1180 | 7.2 | 21.3 | 0.39 | 0.52 | 0.33 | 0.03 | 11.2 |
| March 14 | | | | | | | | | | | | |
| North | 7.00 | 54.0 | 6.3 | | 210 | 6.4 | 7.98 | 1.35 | 1.99 | | 1 | 97.4 |
| Dredge | 6.90 | 38.3 | 5.2 | | 150 | 5.5 | 7.32 | 0.93 | 1.33 | | 1 | 92.2 |
| Center | 8.87 | 41.2 | 10.6 | | 160 | 3.8 | 4.93 | 0.62 | 1.52 | | 0.74 | 69.4 |
| Southeast | 8.50 | 51.0 | 13.5 | | | 5.3 | 6.03 | 1.07 | 1.91 | | 0.9 | 60.8 |
| April 24 | | | | | | | | | | | | |
| North | 8.17 | 147 | 11.8 | 35.8 | | 4.8 | 12.4 | 0.26 | 0.63 | 0.27 | 0.15 | 9.4 |
| Dredge | 8.18 | 146 | 11.8 | 28.3 | | 5.3 | 12.9 | 0.26 | 0.54 | 0.32 | 0.08 | 7.0 |
| Center | 8.22 | 145 | 12.1 | 33.2 | | 5.8 | 12.8 | 0.23 | 0.56 | 0.21 | 0.21 | 5.8 |
| Southeast | 8.14 | 138 | 11.1 | 30.6 | | 5.8 | 12.5 | 0.20 | 0.56 | 0.33 | 0.29 | 9.4 |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity $\mu$mhos/cm at 25o C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite $\mu$g $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 8, 1970 | | | | | | | | | | | | |
| North | 8.10 | 149 | | | | 6.5 | 10.4 | 0.23 | 0.26 | 0.29 | 0.09 | 4.6 |
| Dredge | 8.11 | 149 | 7.8 | | | 5.5 | 11.0 | 0.22 | 0.32 | 0.29 | 0.08 | 4.6 |
| Center | 8.08 | 148 | | | | 5.1 | 10.6 | 0.23 | 0.33 | 0.35 | 0.09 | 4.6 |
| Southeast | 8.26 | 148 | 8.2 | | | 5.1 | 9.5 | 0.21 | 0.30 | 0.27 | 0.06 | 5.2 |
| 27 | | | | | | | | | | | | |
| North | 8.30 | 147 | | 24.9 | 785 | 4.8 | 10.9 | 0.32 | 0.46 | 0.37 | 0.14 | 0.0 |
| Dredge | 8.27 | 155 | | 22.6 | 785 | 5.5 | 10.9 | 0.31 | 0.50 | 0.26 | 0.22 | 0.0 |
| Center | 8.35 | 155 | | 27.2 | 779 | 5.5 | 10.9 | 0.31 | 0.52 | 0.37 | 0.15 | 1.26 |
| Southeast | 8.34 | 156 | | 24.0 | 785 | 5.5 | 10.4 | 0.32 | 0.56 | 0.27 | 0.17 | 0.5 |
| June 4 | | | | | | | | | | | | |
| North | 8.27 | 153 | 9.45 | 17.9 | 733 | 5.5 | 10.9 | 0.32 | 0.47 | 0.15 | 0.11 | 1.6 |
| Dredge | 8.22 | 156 | 8.35 | 17.9 | 712 | 4.3 | 10.5 | 0.34 | 0.48 | 0.17 | 0.14 | 3.2 |
| Center | 8.27 | 157 | 8.9 | 19.4 | 795 | 4.8 | 10.7 | 0.32 | 0.45 | 0.18 | 0.15 | 1.6 |
| Southeast | 8.33 | 158 | 9.5 | 19.6 | 806 | 5.1 | 9.5 | 0.35 | 0.49 | 0.30 | 0.12 | 1.6 |
| 11 | | | | | | | | | | | | |
| North | 8.20 | 160 | | 15.9 | 800 | 4.8 | 11.0 | 0.31 | 0.48 | 0.37 | 0.07 | 3.4 |
| Dredge | 8.31 | 163 | 7.8 | 18.1 | 800 | 5.1 | 11.5 | 0.35 | 0.49 | 0.55 | 0.03 | 3.2 |
| Center | 8.24 | 161 | 7.4 | 17.6 | 800 | 4.8 | 11.3 | 0.30 | 0.47 | 0.49 | 0.05 | 4.5 |
| Southeast | 8.74 | 165 | 9.2 | 25.0 | 800 | 4.3 | 8.5 | 0.42 | 0.92 | 0.40 | 0.06 | 1.6 |

Appendix [illegible] Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite mg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June 18, 1970 | | | | | | | | | | | | |
| North | 8.23 | 153 | 7.9 | 35.6 | 779 | 5.05 | 12.4 | 0.33 | 0.58 | 0.225 | 0.026 | 4.91 |
| Dredge | 8.29 | 157 | 9.15 | 52.3 | 779 | 5.53 | 12.3 | 0.33 | 0.57 | 0.25 | 0.030 | 4.70 |
| Center | 8.17 | 153 | 8.15 | 31.7 | 779 | 4.32 | 12.3 | 0.31 | 0.53 | 0.20 | 0.031 | 3.98 |
| Southeast | 8.55 | 153 | 8.10 | 33.7 | 779 | 5.77 | 10.8 | 0.55 | 1.10 | 0.27 | 0.021 | 3.08 |
| July 1 | | | | | | | | | | | | |
| North | 8.87 | 150 | 12.2 | | 769 | 4.8 | 14.2 | 0.22 | 0.36 | 0.12 | 0.0175 | 5.52 |
| Dredge | 8.89 | 146 | 10.7 | 29.8 | 769 | 3.6 | 12.1 | 0.2 | 0.45 | 0.11 | 0.019 | 6.66 |
| Center | 8.75 | 149 | 9.7 | 19.7 | 779 | 0.7 | 13.8 | 0.24 | 0.52 | 0.15 | 0.040 | 3.39 |
| Southeast | 9.55 | 108 | 11.5 | 24.7 | 706 | 2.6 | 12.6 | 0.36 | 0.69 | 0.09 | 0.030 | 4.36 |
| 7 | | | | | | | | | | | | |
| North | 9.12 | 147 | 11.05 | | 769 | 4.3 | 14.6 | 0.20 | 1.04 | 0.00 | 0.010 | 3.04 |
| Dredge | 8.67 | 148 | | | 779 | 4.8 | 13.7 | 0.34 | 0.54 | 0.00 | 0.010 | 2.40 |
| Center | 8.49 | 147 | 7.4 | | 789 | 4.3 | 15.0 | 0.37 | 0.63 | 0.265 | 0.009 | 4.59 |
| Southeast | 9.44 | 116 | | | 717 | 4.3 | 7.5 | 0.42 | 0.80 | 0.00 | 0.010 | 1.63 |
| 14 | | | | | | | | | | | | |
| North | 9.11 | 148 | 12.6 | | 773 | 6.01 | 15.3 | 0.33 | 0.53 | 0.30 | 0.006 | 0.42 |
| Dredge | 9.06 | 146 | 11.3 | | 773 | 5.29 | 15.7 | 0.37 | 0.72 | 0.34 | 0.010 | 2.00 |
| Center | 8.82 | 149 | 7.6 | | 784 | 6.01 | 16.2 | 0.44 | 0.63 | 0.39 | 0.011 | [illegible] |
| Southeast | 9.97 | 112 | 13.2 | | 722 | 3.61 | [illegible] | 0.14 | 0.58 | 0.26 | [illegible] | [illegible] |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/l | Dissolved Oxygen mg $O_2$/l | COD mg/l | Conductivity µmhos/cm at 25° C. | Chloride mg. Cl/l | Silica mg $SiO_2$/l | Ortho Phosphate mg $PO_4$/l | Total Phosphorus mg $PO_4$/l | Ammonia mg $NH_3$-N/l | Nitrate mg $NO_3$-N/l | Nitrite µg $NO_2$-N/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 21, 1970 | | | | | | | | | | | | |
| North | 8.89 | 150 | 8.9 | | 784 | 5.77 | 17.7 | 0.72 | 1.25 | 0.28 | 0.001 | 2.5 |
| Dredge | 8.85 | 150 | 8.7 | | 784 | 5.05 | 15.2 | 0.67 | 1.29 | 0.19 | 0.005 | 3.2 |
| Center | 8.57 | 148 | 6.8 | | 794 | 5.53 | 18.2 | 0.71 | 1.06 | 0.21 | 0.056 | 2.6 |
| Southeast | 9.58 | 107 | 11.0 | | 712 | 5.33 | 8.3 | 0.50 | 1.04 | 0.19 | 0.003 | 3.6 |
| 28 | | | | | | | | | | | | |
| North | 9.10 | 152 | 11.5 | | 768 | 5.53 | 18.5 | 0.83 | 1.19 | 0.11 | 0.01 | 1.36 |
| Dredge | 9.07 | 170 | 12.1 | | 778 | 5.29 | 19.4 | 0.88 | 1.16 | 0.27 | 0.02 | 1.23 |
| Center | 8.92 | 152 | 8.9 | | 778 | 6.25 | 18.0 | 0.88 | 1.10 | 0.15 | 0.01 | 2.35 |
| Southeast | 10.11 | 114 | 14.8 | | 747 | 5.77 | 8.4 | 0.10 | 0.50 | 0.34 | 0.00 | 1.00 |
| Aug. 4 | | | | | | | | | | | | |
| North | 8.89 | 162 | 5.8 | 51.6 | 778 | 5.53 | 20.7 | 1.07 | 1.56 | 0.25 | 0.00 | 3.34 |
| Dredge | 8.87 | 161 | 6.2 | >55.0 | 788 | 5.77 | 19.8 | 1.11 | 1.66 | 0.20 | 0.02 | 2.22 |
| Center | 8.94 | 160 | 6.9 | >55.0 | 778 | 5.29 | 19.4 | 0.97 | 1.48 | 0.36 | 0.00 | 2.78 |
| Southeast | 9.47 | 132 | 7.4 | 54.5 | 747 | 5.29 | 13.5 | 0.75 | 1.29 | 0.26 | 0.03 | 3.34 |
| 11 | | | | | | | | | | | | |
| North | 9.33 | 158 | 19.0 | 71.7 | 758 | 5.53 | 19.5 | 0.93 | 1.71 | 0.26 | 0.000 | 3.05 |
| Dredge | 9.12 | 159 | 15.0 | 62.6 | 768 | 5.77 | 19.9 | 1.14 | 1.45 | 0.18 | 0.058 | 4.09 |
| Center | 9.17 | 156 | 15.2 | 53.2 | 768 | 5.29 | 23.9 | 1.09 | 1.46 | 0.29 | 0.010 | 2.84 |
| Southeast | 10.17 | 136 | 15.8 | 86.4 | 758 | 5.53 | 12.4 | 0.18 | 1.45 | 0.25 | 0.000 | 6.75 |

## Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3/1$ | Dissolved Oxygen mg $O_2/1$ | COD mg/1 | Conductivity µmhos/cm at 25o C. | Chloride mg Cl/1 | Silica mg $SiO_2/1$ | Ortho Phosphate mg $PO_4/1$ | Total Phosphorus mg $PO_4/1$ | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 18, 1970 | | | | | | | | | | | | |
| North | 9.04 | 163 | 9.2 | 62.0 | 788 | 4.8 | 27.8 | 1.28 | 1.98 | 0.10 | 0.017 | 4.30 |
| Dredge | 9.19 | 163 | 9.0 | 56.9 | 778 | 4.8 | 27.0 | 1.16 | 1.89 | 0.07 | 0.013 | 3.16 |
| Center | 8.97 | 163 | 9.1 | 55.5 | 788 | 4.8 | 26.3 | 1.13 | 1.92 | 0.07 | 0.014 | 3.26 |
| Southeast | 9.63 | 135 | 11.4 | 61.3 | 730 | 5.8 | 14.3 | 0.61 | 1.51 | 0.10 | 0.009 | 4.20 |
| Sept. 3 | | | | | | | | | | | | |
| North | 9.23 | 173 | | 54.9 | 777 | 5.4 | 26.2 | 1.44 | 2.13 | 0.07 | 0.170 | 1.56 |
| Dredge | 9.32 | 176 | | 59.8 | 797 | 6.7 | 26.3 | 1.48 | 1.96 | 0.06 | 0.036 | 4.19 |
| Center | 9.23 | 176 | | 54.6 | 787 | 5.7 | 26.5 | 1.61 | 1.91 | 0.09 | 0.027 | 2.09 |
| Southeast | 9.99 | 138 | | 71.3 | 747 | 5.4 | 20.7 | 0.53 | 1.39 | 0.10 | 0.020 | 3.13 |
| 22 | | | | | | | | | | | | |
| North | 9.16 | 177 | 9.8 | 46.7 | 806 | 5.94 | 21.9 | 1.50 | 2.11 | 0.01 | 0.013 | 1.25 |
| Dredge | 9.16 | 179 | 10.9 | 54.5 | 800 | 8.78 | 23.9 | 1.52 | 2.15 | 0.04 | 0.010 | 2.18 |
| Center | 9.15 | 176 | 10.2 | 50.2 | 800 | 6.20 | 23.9 | 1.56 | 2.68 | 0.06 | 0.021 | 2.07 |
| Southeast | 9.14 | 168 | 10.0 | 58.1 | 786 | 7.23 | 22.5 | 1.26 | 2.36 | 0.03 | 0.005 | 1.61 |
| Oct. 6 | | | | | | | | | | | | |
| North | 9.03 | 186 | 9.6 | 48.0 | 873 | 5.68 | 23.3 | 1.74 | 2.81 | 0.03 | 0.011 | 1.46 |
| Dredge | 9.07 | 187 | 9.5 | 46.7 | 873 | 6.20 | 24.5 | 1.66 | 2.80 | 0.24 | 0.020 | 2.02 |
| Center | 9.07 | 186 | 9.5 | 42.7 | 873 | 5.68 | 24.5 | 1.71 | 2.34 | 0.01 | 0.018 | 1.40 |
| Southeast | 8.80 | 189 | 9.4 | 61.3 | 883 | 6.72 | 27.6 | 1.48 | 3.03 | 0.04 | 0.002 | 1.00 |
| 13 | | | | | | | | | | | | |
| Dredge | 8.93 | 185 | 10.4 | 51.5 | 874 | 6.72 | 24.8 | 1.61 | 3.01 | 0.15 | 0.125 | 1.50 |

## Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25o C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 21, 1970 | | | | | | | | | | | | |
| North | 8.97 | 188 | 10.6 | 38.4 | 893 | 6.20 | 18.0 | 1.70 | 4.33 | 0.03 | 0.127 | 4.44 |
| Dredge | 8.97 | 188 | 10.8 | 38.4 | 873 | 6.20 | 16.8 | 1.72 | 2.02 | 0.12 | 0.025 | 4.64 |
| Center | 8.98 | 187 | 11.0 | 36.1 | 904 | 6.72 | 18.8 | 1.70 | 3.57 | 0.18 | 0.055 | 2.62 |
| Southeast | 8.66 | 186 | 9.8 | 47.7 | 883 | 6.72 | 18.0 | 1.07 | 1.66 | 0.05 | 0.082 | 10.8 |
| Nov. 3 | | | | | | | | | | | | |
| North | 8.91 | 190 | 12.5 | 36.0 | 873 | 6.20 | 20.0 | 1.66 | 3.23 | 0.02 | 0.057 | 1.44 |
| Dredge | 8.85 | 190 | 12.3 | 39.7 | 873 | 6.20 | 14.6 | 1.72 | 2.46 | 0.02 | 0.051 | 1.11 |
| Center | 8.85 | 190 | 13.0 | 39.5 | 873 | 6.20 | 16.3 | 1.67 | 2.31 | 0.02 | 0.000 | 3.23 |
| Southeast | 8.55 | 185 | 12.2 | 43.0 | 893 | 5.68 | 15.5 | 1.08 | 1.92 | 0.03 | 0.078 | 1.31 |
| Dec. 19 | | | | | | | | | | | | |
| North | 8.18 | 212 | 10.8 | 30.4 | 992 | 6.20 | 20.8 | 1.70 | 2.14 | 0.05 | 0.100 | 3.55 |
| Dredge | 8.14 | 225 | 10.0 | 36.8 | 1022 | 7.23 | 18.6 | 1.58 | 1.95 | 0.39 | 0.123 | 2.87 |
| Center | 8.11 | 219 | | 31.8 | 1022 | 7.75 | 21.3 | 1.61 | 2.02 | 0.89 | 0.102 | 3.33 |
| Southeast | 8.23 | 223 | 11.2 | 36.0 | 1052 | 7.23 | 18.0 | 0.98 | 1.48 | 0.11 | 0.029 | 2.22 |
| Jan. 19, 1971 | | | | | | | | | | | | |
| North | 7.93 | 240 | 6.1 | 31.4 | 1082 | 6.97 | 31.3 | 1.99 | 2.07 | 0.45 | 0.19 | 5.24 |
| Dredge | 7.84 | 239 | 5.0 | 32.8 | 1092 | 6.97 | 28.7 | 2.02 | 2.09 | 0.12 | 0.22 | 5.52 |
| Center | 7.78 | 240 | 4.1 | 29.4 | 1092 | 6.46 | 28.9 | 1.84 | 1.74 | 0.21 | 0.21 | 4.84 |
| Southeast | 7.77 | 265 | 4.5 | 31.9 | 1208 | 4.91 | 24.4 | 1.52 | 1.56 | 0.41 | 0.11 | 4.12 |

Appendix C  Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. 12, 1971 | | | | | | | | | | | | |
| North | 7.71 | 262 | 2.9 | 37.0 | 1267 | 6.20 | 37.4 | 1.69 | 1.79 | 0.28 | 0.237 | 3.01 |
| Dredge | 7.52 | 261 | 1.3 | 30.9 | 1257 | 6.20 | 38.1 | 1.72 | 1.88 | 0.52 | 0.181 | 2.16 |
| Center | 7.82 | 277 | 2.9 | 36.4 | 1309 | 5.68 | 40.1 | 1.82 | 4.77 | 0.30 | 0.205 | 3.01 |
| Southeast | 7.66 | 290 | 3.8 | 37.2 | 1330 | 5.94 | 41.4 | 1.93 | 8.20 | 0.37 | 0.121 | 2.38 |
| March 5 | | | | | | | | | | | | |
| North | 7.54 | 154 | 5.1 | 39.7 | 720 | 5.4 | 20.3 | 1.52 | 1.90 | 0.38 | 0.585 | 31.3 |
| Dredge | 7.37 | 132 | 5.0 | 49.9 | 633 | 6.2 | 19.1 | 2.08 | 2.78 | 0.76 | 1.315 | 32.5 |
| Center | 7.48 | 194 | 3.1 | 47.6 | 891 | 6.5 | 27.7 | 2.03 | 2.50 | 0.67 | 0.635 | 25.7 |
| Southeast | 7.47 | 198 | 3.0 | 39.2 | 900 | 6.2 | 26.6 | 1.86 | 2.22 | 0.69 | 0.495 | 29.8 |
| April 12 | | | | | | | | | | | | |
| North | 8.56 | 163 | 13.3 | 25.6 | 731 | 5.3 | 17.2 | 1.03 | 1.50 | 0.08 | 0.009 | 20 |
| Dredge | 8.40 | 163 | 12.5 | 25.6 | 731 | 4.9 | 18.5 | 1.03 | 1.47 | 0.02 | 0.025 | 20 |
| Center | 8.37 | 163 | 11.8 | 23.9 | 731 | 4.8 | 15.5 | 1.01 | 1.49 | 0.03 | 0.030 | 13 |
| Southeast | 8.42 | 139 | 12.8 | 25.7 | 632 | 4.8 | 17.2 | 0.71 | 1.23 | 0.05 | 0.027 | 20 |
| 30 | | | | | | | | | | | | |
| North | 8.54 | 164 | 10.7 | 35.7 | 726 | 5.3 | 26.9 | 0.80 | 0.80 | 0.00 | 0.03 | 12.0 |
| Dredge | 8.49 | 162 | 11.0 | 28.4 | 726 | 5.1 | 21.3 | 0.83 | 0.83 | 0.00 | 0.02 | 19.8 |
| Center | 8.46 | 162 | 10.7 | 32.3 | 726 | 5.9 | 20.5 | 0.80 | 0.80 | 0.00 | 0.02 | 21.0 |
| Southeast | 8.29 | 154 | 10.3 | 28.1 | 706 | 4.9 | 21.0 | 0.49 | 0.88 | 0.06 | 0.03 | 19.8 |

## Appendix C Results of Chemical Analyses of Lake Herman

| Date | pH | Alkalinity mg $CaCO_3$/1 | Dissolved Oxygen mg $O_2$/1 | COD mg/1 | Conductivity µmhos/cm at 25° C. | Chloride mg Cl/1 | Silica mg $SiO_2$/1 | Ortho Phosphate mg $PO_4$/1 | Total Phosphorus mg $PO_4$/1 | Ammonia mg $NH_3$-N/1 | Nitrate mg $NO_3$-N/1 | Nitrite µg $NO_2$-N/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 12, 1971 | | | | | | | | | | | | |
| North | 8.36 | 166 | 9.85 | 29.6 | 736 | 5.2 | 11.5 | 0.68 | 0.68 | 0.00 | 0.01 | 0.0 |
| Dredge | 8.39 | 167 | 9.9 | 19.9 | 736 | 5.4 | 16.2 | 0.69 | 0.75 | 0.04 | 0.02 | 0.0 |
| Center | 8.35 | 166 | 10.2 | 20.8 | 736 | 4.6 | 8.7 | 0.69 | 0.70 | 0.03 | 0.02 | 0.0 |
| Southeast | 8.28 | 164 | 9.9 | 20.1 | 746 | 4.6 | 9.0 | 0.48 | 0.56 | 0.05 | 0.005 | 0.0 |
| 27 | | | | | | | | | | | | |
| North | 8.62 | 170 | 21.4 | 36.3 | 730 | 4.9 | 19.2 | 0.60 | 0.76 | 0.02 | 0.008 | 4 |
| Dredge | 8.59 | 170 | 11.9 | 35.8 | 710 | 4.7 | 19.1 | 0.59 | 0.78 | 0.02 | 0.012 | 1 |
| Center | 8.65 | 170 | 12.5 | 37.3 | 710 | 5.0 | 19.1 | 0.59 | 0.85 | 0.02 | 0.006 | 4 |
| Southeast | 8.51 | 171 | 11.7 | 34.7 | 730 | 4.6 | 21.3 | 0.40 | 0.65 | 0.00 | 0.005 | 4 |

Appendix [illegible] Results of Chemical Analyses of Lake Herman

| Date | Temperature °C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June, 1968 | 20.7 | | 33 | | 520 | | | | | | | |
| July | 21.3 | | 20 | | 495 | | | | | | | |
| August | | | | | | | | | | | | |
| September | 17 | | 35 | | 501 | | | | | | | |
| October | 13 | | 25 | | 501 | | | | | | | |
| November | 11 | | | | 517 | | | | | | | |
| December | 0 | | | | 550 | | | | | | | |
| Jan., 1969 | 1 | | | | 704 | | | | | | | |
| February | | | | | 682 | | | | | | | |
| March | | | | | 246 | | | | | | | |
| Mar. [illegible]<br>Center | | | | | 248 | | | | | | | |

Appendix [illegible] Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June 26, 1969 | | | | | | | | | | | | |
| Center | 18 | | | | 338 | | | | | | | |
| July 3 | | | | | | | | | | | | |
| Center | 22.5 | | 58 | | 336 | | | | | | | |
| 10 | | | | | | | | | | | | |
| Dredge | 25 | | 121 | | 342 | | | | | | | |
| Center | 25 | | 144 | | 342 | | | | | | | |
| 17 | | | | | | | | | | | | |
| Dredge | 26 | | 130 | | 350 | | | | | | | |
| Center | 27 | | 110 | | 342 | | | | | | | |
| 24 | | | | | | | | | | | | |
| Dredge | | | | | 360 | | | | | | | |
| Center | | | | | 354 | | | | | | | |
| Southeast | | | | | 383 | | | | | | | |
| 31 | | | | | | | | | | | | |
| Dredge | 23 | | 98 | | 369 | | | | | | | 0.0 |
| Center | 22.5 | | 100 | | 370 | | | | | | | 6.6 |
| Southeast | [illegible] | | 70 | | 380 | | | | | | | 2.2 |

Appendix . Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (in) | Turbidity (Jackson Turbidity Units) | Hardness mg CaCO$_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 7, 1969 | | | | | | | | | | | | |
| Dredge | 24.5 | | 30 | | 392 | | | | | | | |
| Center | 24.0 | | 75 | | 379 | | | | | | | 13.0 |
| Southeast | 24.0 | | 54 | | 384 | | | | | | | 13.4 |
| 15 | | | | | | | | | | | | |
| Dredge | 24.8 | | 80 | | 393 | | | | | | | 17.0 |
| Center | 23.5 | | 77 | | 393 | | | | | | | 15.6 |
| Southeast | 23.5 | | [illegible] | | 393 | | | | | | | 15.4 |
| 22 | | | | | | | | | | | | |
| Dredge | 23.0 | 7 | 72 | | 390 | | | | | | | 14.5 |
| Center | 22.5 | 8 | 77 | | 379 | | | | | | | 13.3 |
| Southeast | 22.7 | 6 | 74 | | 384 | | | | | | | 14.7 |
| 28 | | | | | | | | | | | | |
| Dredge | 24 | 7 | 60 | | 386 | | | | | | | 12.8 |
| Center | 24 | 8 | 62 | | 378 | | | | | | | 14.7 |
| Southeast | 24 | 5 | 56 | | 386 | | | | | | | 11.8 |
| Sept. 4 | | | | | | | | | | | | |
| Dredge | 22 | 7 | 55 | | 388 | | | | | | | |
| Center | [illegible] | [illegible] | [illegible] | | 394 | | | | | | | |
| | | | | | [illegible] | | | | | | | |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sept. 17, 1969 | | | | | | | | | | | | |
| Dredge | | | | | 395 | | | | | | | |
| Center | 19 | 7.5 | 60 | | 395 | | | | | | | |
| Southeast | 19 | 5 | 53 | | 397 | | | | | | | |
| Oct. 4 | | | | | | | | | | | | |
| Dredge | 15 | 5.5 | 78 | | 404 | | | | | | | 15.0 |
| Center | 15 | 7 | 76 | | 402 | | | | | | | 15.9 |
| Southeast | 15 | | | | 404 | | | | | | | |
| 19 | | | | | | | | | | | | |
| Dredge | 6 | 6 | 85 | | 404 | | | | | | | 13.8 |
| Center | 6 | 8 | 104 | | 397 | | | | | | | 13.2 |
| Southeast | 6 | 5 | 82 | | 395 | | | | | | | 16.4 |
| Nov. 3 | | | | | | | | | | | | |
| Dredge | 3 | 6 | 78 | | 402 | | | | | | | 13.3 |
| Center | 3 | 7 | 78 | | 402 | | | | | | | 16.7 |
| Southeast | 3 | 5 | 75 | | 403 | | | | | | | 12.3 |
| North | 3 | 7 | 70 | | 404 | | | | | | | 18.0 |
| Dec. 21 | | | | | | | | | | | | |
| Dredge | 0 | 7 | 120 | | 459 | | | | | | | 15.0 |
| Center | 0 | 7 | 85 | | 457 | | | | | | | [illegible] |

Appendix C  Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 4, 1970 | | | | | | | | | | | | |
| North | 0 | 5 | 152 | | 489 | | | | | | | |
| Southeast | 0 | 9 | 274 | | 536 | | | | | | | |
| 23 | | | | | | | | | | | | |
| North | 0.0 | 3 | | | 572 | 116 | 0.02 | 0.12 | 67.3 | 0.03 | 47.5 | 23.6 |
| Dredge | 0.0 | 4 | | | 509 | 111 | 0.04 | 0.11 | 57.9 | 0.04 | 33.5 | 20.0 |
| Center | 0.0 | 6 | | | 503 | 103 | 0.03 | 0.11 | 60.6 | 0.03 | 31.0 | 19.7 |
| Southeast | 0.0 | 6 | | | 564 | 113 | 0.03 | 0.12 | 64.2 | 0.03 | 43.0 | 22.7 |
| Feb. 6, 7 | | | | | | | | | | | | |
| North | | 3 | | | 552 | 111 | 0.01 | 0.02 | 64.3 | 0.25 | 43 | 23.0 |
| Dredge | | 5 | | | 521 | 105 | 0.01 | 0.05 | 60.9 | 0.15 | 44 | 21.7 |
| Center | 0.0 | 7 | 213 | | 525 | 117 | 0.01 | 0.04 | 61.9 | 0.06 | 42 | 21.6 |
| Southeast | 0.0 | 5 | 152 | | 616 | 105 | 0.01 | 0.15 | 66.6 | 0.29 | 43 | 21.6 |
| March 14 | | | | | | | | | | | | |
| North | | | | 30 | 93.4 | 19.8 | 0.01 | 0.30 | 61.4 | 0.06 | 4.75 | 13.2 |
| Dredge | | | | 34 | 91.4 | 23.8 | 0.01 | 0.40 | 24.3 | 0.13 | 6.05 | 12.5 |
| Center | | | | 28 | 93.4 | 19.0 | 0.00 | 0.12 | 25.4 | 0.14 | 6.80 | 10.5 |
| Southeast | | | | 24 | 139 | 17.5 | 0.00 | 0.08 | 24.8 | 0.10 | 5.98 | 10.7 |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | Temperature o C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 24, 1970 | | | | | | | | | | | | |
| North | 6.0 | | | 25 | 356 | 73.8 | 0.01 | 0.06 | 10.1 | 0.05 | 30.2 | 15.1 |
| Dredge | 7 | | 40 | 27 | 356 | 69.8 | 0.00 | 0.04 | 7.0 | 0.02 | 30.2 | 15.3 |
| Center | 6 | | 30 | 24 | 338 | 69.5 | 0.00 | 0.02 | 6.0 | 0.02 | 27.9 | 15.1 |
| Southeast | 6 | | 35 | 25 | 322 | 69.3 | 0.00 | 0.05 | 6.5 | 0.03 | 27.8 | 14.5 |
| May 8 | | | | | | | | | | | | |
| North | 17 | 7 | 75 | 14 | 391 | 72.9 | 0.00 | 0.05 | 26.6 | 0.03 | 32.5 | 16.0 |
| Dredge | 17 | 7 | 70 | 17 | 359 | 73.8 | 0.00 | 0.08 | 26.6 | 0.03 | 29.4 | 16.2 |
| Center | 17 | 8 | 78 | 14 | 375 | 74.2 | 0.00 | 0.04 | 26.7 | 0.02 | 30.3 | 16.2 |
| Southeast | 17 | 6 | 80 | 14 | 344 | 73.8 | 0.00 | 0.05 | 27.3 | 0.03 | 30.3 | 16.0 |
| 27 | | | | | | | | | | | | |
| North | | | | 16 | 373 | 76.0 | 0.00 | 0.03 | 27.3 | 0.01 | 31.4 | 18.0 |
| Dredge | | | | 16 | 365 | 75.1 | 0.00 | 0.04 | 27.0 | 0.03 | 33.0 | 17.8 |
| Center | | | | 16 | 368 | 78.1 | 0.00 | 0.03 | 27.4 | 0.02 | 31.0 | 18.0 |
| Southeast | | | | 17 | 371 | 77.7 | 0.00 | 0.03 | 27.3 | 0.02 | 31.8 | 18.1 |
| June 4 | | | | | | | | | | | | |
| North | 21 | | 125 | 15 | 451 | 80.4 | 0.01 | 0.02 | 28.4 | 0.05 | | |
| Dredge | 22 | | 200 | 15 | 395 | 77.7 | 0.00 | 0.02 | 28.0 | 0.03 | | |
| Center | 22 | | 180 | 15 | 385 | 78.1 | 0.01 | 0.02 | 28.3 | 0.03 | | |
| Southeast | 22 | | 125 | 15 | 388 | 78.9 | 0.01 | 0.02 | 28.8 | 0.02 | | |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June 11, 1970 | | | | | | | | | | | | |
| North | 22.5 | | | 12 | 379 | 90.7 | 0.01 | 0.04 | 44.5 | 0.03 | 31 | 16.6 |
| Dredge | 22.5 | | | 13 | 375 | 82.4 | 0.00 | 0.04 | 44.5 | 0.05 | 31 | 16.9 |
| Center | 22.5 | | | 13 | 431 | 82.0 | 0.00 | 0.03 | 42.7 | 0.03 | 30 | 17.0 |
| Southeast | 22.5 | | | 16 | 405 | 83.7 | 0.01 | 0.03 | 43.7 | 0.05 | 31 | 16.8 |
| 18 | | | | | | | | | | | | |
| North | 23 | 9 | 48 | | 388 | 80.3 | 0.00 | 0.05 | 43.3 | 0.04 | 31 | 16.7 |
| Dredge | 22 | 7 | 64 | | 428 | 85.9 | 0.00 | 0.06 | 44.5 | 0.04 | 30 | 16.7 |
| Center | 22.5 | 9 | 86 | | 418 | 82.8 | 0.00 | 0.03 | 43.8 | 0.03 | 31 | 16.9 |
| Southeast | 22 | 9 | 75 | | 375 | 82.0 | 0.00 | 0.03 | 44.5 | 0.08 | 31 | 15.3 |
| July 1 | | | | | | | | | | | | |
| North | 27.5 | 8 | 80 | 27.0 | 375 | 82.0 | 0.00 | 0.02 | 43.8 | 0.01 | 30 | 17.2 |
| Dredge | 27 | 8 | 96 | 24.7 | 369 | 79.8 | 0.04 | 0.03 | 44.5 | 0.02 | 31 | 16.9 |
| Center | 27 | 9 | 105 | 25.4 | 372 | 82.0 | 0.00 | 0.05 | 44.5 | 0.03 | 31 | 16.7 |
| Southeast | 28.5 | 6 | 74 | 30.2 | 362 | 63.4 | 0.00 | 0.02 | 45.7 | 0.12 | 33 | 16.1 |
| 7 | | | | | | | | | | | | |
| North | 25 | 8 | 50 | 25.0 | 365 | 79.0 | 0.00 | 0.04 | 45.7 | 0.06 | 31 | 17.2 |
| Dredge | | 8 | 104 | 18.2 | 370 | 77.7 | 0.00 | 0.04 | 45.7 | 0.08 | 31 | 16.9 |
| Center | 24 | 9 | 112 | 19.3 | 375 | 79.4 | 0.00 | 0.04 | 46.3 | 0.11 | 31 | 17.6 |
| Southeast | | 6 | 95 | 23.7 | 341 | 69.2 | 0.00 | 0.01 | 46.3 | 0.11 | 32 | 16.3 |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 14, 1970 | | | | | | | | | | | | |
| North | | 8 | 78 | 21.4 | 388 | 110 | 0.01 | 0.02 | 41.5 | 0.03 | 31 | 16.8 |
| Dredge | 26 | 5 | 56 | 23.0 | 338 | 76.4 | 0.00 | 0.03 | 39.0 | 0.03 | 32 | 17.4 |
| Center | 26 | 6 | 78 | 22.7 | 434 | 73.4 | 0.00 | 0.03 | 39.0 | 0.03 | 32 | 17.2 |
| Southeast | 26.5 | 8 | 78 | 29.3 | 328 | 59.7 | 0.00 | 0.01 | 37.1 | 0.03 | 33 | 16.7 |
| 21 | | | | | | | | | | | | |
| North | 22.5 | 8 | 35 | 44.2 | 412 | 74.7 | 0.00 | 0.01 | 34.1 | 0.03 | 33 | 17.6 |
| Dredge | 22.5 | 7 | 30 | 35.2 | 363 | 82.0 | 0.00 | 0.03 | 36.0 | 0.03 | 32 | 17.2 |
| Center | 21 | 9 | 40 | 32.2 | 387 | 75.5 | 0.00 | 0.06 | 34.1 | 0.04 | 32 | 17.0 |
| Southeast | 22 | 6 | 55 | 28.7 | 320 | 81.1 | 0.00 | 0.03 | 32.3 | 0.06 | 33 | 16.6 |
| 28 | | | | | | | | | | | | |
| North | 26.4 | 7 | 45 | 29.8 | 375 | 73.4 | 0.01 | 0.03 | 32.3 | 0.11 | 34 | 17.4 |
| Dredge | 26.5 | 7 | 47 | 31.4 | 368 | 73.4 | 0.01 | 0.02 | 30.4 | 0.01 | 33 | 17.3 |
| Center | 26 | 8 | 44 | 32.9 | 382 | 73.4 | 0.01 | 0.02 | 31.1 | 0.02 | 33 | 17.2 |
| Southeast | 27 | 6 | 47 | 31.8 | 362 | 75.1 | 0.00 | 0.00 | 30.4 | 0.01 | 35 | 17.2 |
| Aug. 4 | | | | | | | | | | | | |
| North | 23 | 8 | 18 | 43.3 | 375 | 80.7 | 0.00 | 0.00 | 31.6 | 0.06 | 34 | 18.1 |
| Dredge | 23 | 7 | 20 | 35.3 | 375 | 73.4 | 0.00 | 0.02 | 28.1 | 0.06 | 32 | 17.9 |
| Center | 24 | 8 | 30 | 41.6 | 375 | 73.4 | 0.00 | 0.02 | 28.6 | 0.03 | 34 | 17.9 |
| Southeast | 22 | 6 | 25 | 31.3 | 349 | 64.2 | 0.00 | 0.00 | 27.4 | 0.06 | 34 | 18.2 |

Appendix C  Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 11, 1970 | | | | | | | | | | | | |
| North | 27.5 | 7 | | 34.7 | 375 | 78.4 | 0.00 | 0.03 | 39.2 | 0.01 | 32 | 17.5 |
| Dredge | 28 | 7 | | 19.3 | 365 | 77.9 | 0.00 | 0.02 | 38.6 | 0.01 | 32 | 17.2 |
| Center | 26 | 8 | | 22.7 | 370 | 77.5 | 0.00 | 0.02 | 38.6 | 0.01 | 32 | 17.4 |
| Southeast | 28 | 6 | | 34.7 | 340 | 71.1 | 0.00 | 0.02 | 37.0 | 0.01 | 32 | 17.4 |
| 18 | | | | | | | | | | | | |
| North | 24.5 | 7 | 30 | 32.4 | 373 | 79.3 | 0.01 | 0.02 | 40.2 | 0.03 | 33 | 17.7 |
| Dredge | 24.5 | 7 | 35 | 22.4 | 370 | 80.7 | 0.00 | 0.06 | 40.2 | 0.03 | 34 | 17.6 |
| Center | 24.0 | 8 | 32 | 24.7 | 377 | 79.8 | 0.00 | 0.01 | 39.5 | 0.04 | 33 | 17.7 |
| Southeast | 24.5 | 5.5 | 39 | 21.9 | 340 | 71.1 | 0.01 | 0.02 | 37.0 | 0.02 | 38 | 18.0 |
| Sept. 3 | | | | | | | | | | | | |
| North | | 7 | | 26.3 | 395 | 80.2 | 0.00 | 0.02 | 39.2 | 0.02 | 36 | 17.9 |
| Dredge | | 8 | | 27.5 | 385 | 78.9 | 0.01 | 0.03 | 39.2 | 0.02 | 36 | 18.1 |
| Center | | 7 | | 27.5 | 385 | 77.9 | 0.01 | 0.03 | 39.7 | 0.02 | 37 | 18.1 |
| Southeast | | 6 | | 25.6 | 340 | 69.5 | 0.00 | 0.02 | 35.4 | 0.02 | 38 | 18.2 |
| 22 | | | | | | | | | | | | |
| North | 17 | 8 | 33 | 38 | 390 | 81.2 | 0.00 | 0.02 | 40.2 | 0.02 | 38 | 17.5 |
| Dredge | 19 | 7 | 24 | 45 | 390 | 81.2 | 0.00 | 0.10 | 40.8 | 0.04 | 39 | 18.1 |
| Center | 17 | 7 | 32 | 37 | 400 | 82.1 | 0.00 | 0.02 | 41.9 | 0.02 | 38 | 17.6 |
| Southeast | 17 | 5 | 28 | 38 | 385 | 78.4 | 0.00 | 0.02 | 41.9 | 0.04 | 39 | 18.6 |

Appendix C Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | Depth of Water (feet) | Secchi Disk (cm) | Turbidity (Jackson Turbidity Units) | Hardness mg $CaCO_3$/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 6, 1970 | | | | | | | | | | | | |
| North | 15.5 | 7.5 | 37 | 20.5 | 400 | 83.5 | 0.00 | 0.02 | 43.0 | 0.03 | 40 | 18.3 |
| Dredge | 16 | 7 | 41 | 20.5 | 405 | 85.9 | 0.00 | 0.02 | 44.1 | 0.03 | 39 | 18.9 |
| Center | 15.5 | 7 | 48 | 18.4 | 400 | 84.0 | 0.00 | 0.02 | 43.0 | 0.03 | 39 | 18.4 |
| Southeast | 16 | 5 | 28 | 25.9 | 400 | 83.5 | 0.00 | 0.01 | 44.1 | 0.13 | 40 | 19.0 |
| 13 | | | | | | | | | | | | |
| Dredge | 7 | 7 | | 26.3 | 395 | 81.7 | 0.01 | 0.04 | 42.4 | 0.04 | 38 | 18.2 |
| 21 | | | | | | | | | | | | |
| North | 10 | 7 | 56 | 23.5 | 395 | 86.8 | 0.00 | 0.04 | 48.1 | 0.04 | 39 | 18.4 |
| Dredge | 10 | 7 | 50 | 21.0 | 400 | 83.5 | 0.01 | 0.04 | 47.8 | 0.02 | 38 | 18.2 |
| Center | 10 | 7 | 54 | 21.0 | 400 | 83.5 | 0.01 | 0.02 | 48.7 | 0.03 | 38 | 18.2 |
| Southeast | 11 | 5 | 34 | 31.4 | 402 | 80.2 | 0.01 | 0.02 | 49.0 | 0.02 | 39 | 18.4 |
| Nov. 3 | | | | | | | | | | | | |
| North | 3 | 7 | 63 | 19.6 | 421 | 82.1 | 0.01 | 0.03 | 42.5 | 0.02 | 39 | 18.6 |
| Dredge | 3 | 6 | 50 | 21.3 | 408 | 82.1 | 0.00 | 0.03 | 46.5 | 0.04 | 39 | 18.1 |
| Center | 3 | 7 | 41 | 25.8 | 401 | 82.1 | 0.01 | 0.03 | 47.1 | 0.02 | 39 | 18.0 |
| Southeast | 3 | 5 | 43 | 23.1 | 414 | 83.5 | 0.01 | 0.02 | 46.5 | 0.02 | 39 | 18.1 |
| Dec. 19 | | | | | | | | | | | | |
| North | 0.5 | | | 21.1 | 454 | 95.8 | 0.00 | 0.06 | 52.9 | 0.05 | 41.1 | 20.7 |
| Dredge | 0.0 | 6.5 | | 23.2 | 480 | 105 | 0.00 | 0.11 | 53.8 | 0.07 | 40.8 | 20.6 |
| Center | 0.0 | 6.5 | | 21.1 | 480 | 118 | 0.00 | 0.07 | 51.2 | 0.09 | 40.8 | 21.0 |
| Southeast | 0.3 | 3.5 | | 21.1 | 507 | 113 | 0.00 | 0.04 | 56.4 | 0.03 | 41.3 | 21.0 |

## Appendix [illegible] Results of Chemical Analyses of Lake Herman

| Date | Temperature ° C. | [illegible] (feet) | Secchi Disk | Turbidity (Jackson Turbidity Units) | Hardness mg CaCO$_3$/l | Calcium mg Ca/l | Copper mg Cu/l | Iron mg Fe/l | Magnesium mg Mg/l | Manganese mg Mn/l | Sodium mg Na/l | Potassium mg K/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 19, 197 | | | | | | | | | | | | |
| North | [illegible] | | | 25.1 | 612 | 99.4 | 0.01 | 0.03 | 71.8 | 0.[illegible] | 47.0 | 23.0 |
| Dredge | [illegible] | | | 22.4 | 523 | 106 | 0.00 | 0.02 | 61.3 | 0.25 | 44.9 | 22.3 |
| Center | [illegible] | | | 21.9 | 523 | 110 | 0.01 | 0.02 | 62.3 | 0.52 | 46.3 | 22.2 |
| Southeast | [illegible] | [illegible] | | 30.9 | 592 | 126 | | 0.02 | 69.4 | 1.08 | 51.0 | 24.4 |
| Feb. 12 | | | | | | | | | | | | |
| North | [illegible] | [illegible] | | 22.[illegible] | 572 | 116 | 0.01 | 0.04 | 71.1 | 0.66 | 51.9 | 24.0 |
| Dredge | [illegible] | [illegible] | | 22.5 | 553 | [illegible] | | 0.01 | 69.0 | 0.22 | 50.4 | 21.5 |
| Center | [illegible] | [illegible] | | 22.5 | 562 | [illegible] | 0.01 | 0.02 | 82.3 | 0.38 | 52.9 | 25.1 |
| Southeast | 0 | [illegible] | | [illegible] | [illegible] | [illegible] | 0.01 | 0.01 | 71.1 | [illegible] | 53.9 | [illegible] |
| March 5 | | | | | | | | | | | | |
| North | [illegible] | | | 24.[illegible] | 340 | [illegible] | 0.01 | 0.14 | 35.9 | 0.30 | 26.3 | [illegible] |
| Dredge | [illegible] | | | [illegible] | [illegible] | [illegible] | 0.01 | 0.15 | 28.9 | 0.33 | 20.5 | [illegible] |
| Center | [illegible] | | | 26.[illegible] | 40[illegible] | 84.6 | | 0.11 | 47.2 | 0.6[illegible] | 34.6 | 20.3 |
| Southeast | [illegible] | | | 24.2 | 40[illegible] | [illegible] | | 0.15 | 47.2 | 1.[illegible] | 34.6 | 20.5 |
| April 12 | | | | | | | | | | | | |
| North | 8.5 | [illegible] | 41 | [illegible] | 323 | [illegible] | 0.01 | 0.04 | 38.9 | | 28.1 | 14.7 |
| Dredge | 8.5 | [illegible] | 47 | 26.[illegible] | 322 | 68.4 | | 0.04 | 38.3 | | 28.3 | 14.1 |
| Center | [illegible] | 9 | 47 | 28.2 | 321 | [illegible] | | 0.03 | 38.3 | | 27.4 | 14.4 |
| Southeast | 8 | 7 | 42 | 29.4 | 276 | [illegible] | | 0.04 | 32.1 | 0.10 | 23.9 | 12.6 |

Appendix C. Results of Chemical Analyses of Lake Herman

| Date | Temperature °C. | Depth of Water (Feet) | Secchi Disk | Turbidity (Jackson Turbidity Units) | Hardness mg CaCO3/1 | Calcium mg Ca/1 | Copper mg Cu/1 | Iron mg Fe/1 | Magnesium mg Mg/1 | Manganese mg Mn/1 | Sodium mg Na/1 | Potassium mg K/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 30, 1971 | | | | | | | | | | | | |
| North | 11.5 | 9 | 52 | 26.3 | 376 | 69.0 | 0.01 | 0.02 | 39.2 | 0.06 | 29.4 | 14.6 |
| Dredge | 11.5 | 9 | 55 | 26.3 | 373 | 67.4 | 0.01 | 0.01 | 38.6 | 0.05 | 29.8 | 15.0 |
| Center | 11.5 | 9 | | 26.3 | 349 | 69.4 | 0.01 | 0.02 | 38.9 | 0.06 | 29.4 | 14.9 |
| Southeast | 11.5 | 7 | 47 | 32.0 | 321 | 65.6 | 0.01 | 0.03 | 36.5 | 0.16 | 28.5 | 14.3 |
| May 12 | | | | | | | | | | | | |
| North | 15 | 8 | 48 | 30.1 | 345 | 50.0 | 0.01 | 0.02 | 28.0 | 0.05 | 23.1 | 16.6 |
| Dredge | 15 | 8 | 44 | 28.2 | 341 | 62.7 | | 0.02 | 36.5 | 0.03 | 28.5 | 20.3 |
| Center | 15 | 9 | 43 | 30.4 | 349 | 49.7 | | 0.03 | 29.4 | 0.04 | 22.2 | 16.7 |
| Southeast | 15 | 6 | 42 | 30.1 | 341 | 51.5 | | 0.02 | 29.5 | 0.13 | 22.0 | 16.9 |
| May 27 | | | | | | | | | | | | |
| North | 17 | 6 | 58 | 25.9 | 340 | 70.3 | 0.01 | 0.05 | 41.6 | 0.04 | 30.9 | 16.5 |
| Dredge | 16.5 | 12 | 60 | 28.2 | 346 | 71.3 | 0.00 | 0.02 | 41.3 | 0.04 | 31.8 | 15.8 |
| Center | 16 | 8 | 60 | 30.1 | 340 | 69.0 | | 0.05 | 41.0 | 0.06 | 30.7 | 15.4 |
| Southeast | 15 | 6 | 45 | 30.1 | 340 | 72.6 | | 0.05 | 41.0 | | 30.7 | 16.6 |

Appendix O. Description of Silt Traps and Silt Trap Sites.

## Silt Trap No. 1

Silt Trap No. 1 is sixteen feet and nine inches long, three feet and three inches wide, and three feet and three inches high. All of its parts are similar.

The trap is approximately two and one-fourth miles from Lake Herman and is in section [illegible]-6 (see Figure [illegible]). It is the farthest upstream of the eight silt traps in the series and is one-fourth of one mile above Trap No. 2.

Trap No. 1 is in a slough-like expansion of the creek. The creekbed and creek banks are densely covered with vegetation which consists primarily of grasses and sedges. The area surrounding the trap is slough-like and is neither pastured nor cultivated. Approximately seventy feet from the creek is a cultivated field which extends along the creek for [illegible] feet. Above this point, the creek flows through cultivated fields for [illegible] mile.

## Silt Trap No. 2

Silt Trap No. 2 is twenty-[illegible] feet long, three feet and three inches wide, and one foot high. All of its parts are similar.

The trap is approximately one and one-half miles from Lake Herman and in section [illegible] (see Figure [illegible]). It is one-fourth mile below Trap No. 1 and is sixty feet above Trap No. 3. Trap No. 2 is the second trap in the series of eight traps.

Trap No. 2 is in a slough-like expansion of the creek. The creekbed and creek banks are densely covered with vegetation which consists primarily of grasses and sedges.

The area surrounding the trap is slough-like and is neither pastured nor cultivated. Approximately fifty feet from the creek is a cultivated field which extends for approximately 150 feet along one side of the creek. Two hundred feet upstream from the trap the creek flows across a cultivated field for one-fourth mile. None of the creekbed in this field is under cultivation.

## Silt Trap No. 3

Silt Trap No. 3 is sixteen feet and three inches long and three feet and three inches wide. It has three parts which differ in their heights. The main section of the trap is nine feet and nine inches long and eighteen inches high. On each side of the main section is a wing which is three feet and three inches long and one foot high. The main section of the trap lies in the creekbed and the wings are on the creek banks.

Portions of the trap were countersunk in the creekbed and creek banks so that they would lie level.

Trap No. 3 is approximately one and one-half miles from Lake Herman and is in Section J-6 (see Figure 3). It is sixty feet below Trap No. 2 and 195 feet above Trap No. 4. Trap No. 3 is the third trap in a series of eight traps, and it is in the same pasture as Traps No. 2-8.

Trap No. 3 is in a creekbed which is approximately ten feet wide and two feet deep. The creek bottom is moderately well covered with vegetation which consists primarily of sedges, grasses, and invader species. The creek banks are nearly vertical and lack vegetation.

### Silt Trap No. 4

Silt Trap No. 4 is forty-two feet and three inches long and three feet and three inches wide. It has three parts which differ in their heights. The main section of the trap is nineteen feet and six inches long and three feet and three inches high. On each side of the main section is a wing. One wing is thirteen feet long and one foot high, and the other wing is nine feet and nine inches long and one foot high. The main section of the trap lies in the creekbed and the wings are on the banks of the creek.

Trap No. 4 is approximately one and one-half miles from Lake Herman and is in section J-6 (see Figure 3). It is 195 feet below Trap No. 3 and 375 feet above Trap No. 5. Trap No. 4 is the fourth trap in a series of eight traps, and it is in the same pasture as Traps No. 2-8.

### Silt Trap No. 5

Silt Trap No. 5 is twenty-nine feet and three inches long and three feet and three inches wide. It has three major parts which differ in their heights. The main section of the trap is nine feet and nine inches long and three feet and three inches high. On each side of the main section is a wing which is nine feet and nine inches long. Each wing has two parts. The bagion at the end of each wing is one foot high. The next two gabions (nearest the main section) in each wing are eighteen inches high. The main section of the trap is countersunk to varying degrees which range from none in the middle to sixteen inches near the creek bank.

Trap No. 5 is approximately one and one-half miles from Lake Herman and is in Section J-6 (see Figure 3). It is 375 feet below Trap No. 4 and 275 feet above Trap No. 6. Trap No. 5 is the fifth trap in a series of eight traps, and it is in the same pasture as Traps No. 2-8.

Trap No. 5 is in an eroded creekbed which has very little vegetation during the spring months. In early summer, various invader species give moderate cover to the creekbed. The creek is approximately ten feet wide and two feet deep.

### Silt Trap No. 6

Silt Trap No. 6 is nineteen feet and six inches long and three feet and three inches wide. It has three parts which differ in their heights. The main section of the trap is six feet and six inches long and three feet and three inches high. On each side of the main section is a wing which is three feet and three inches long and one foot high. The main section lies in the creekbed and the wings lie partially in the creekbed and partially on the creek banks.

Trap No. 6 is approximately one and one-half miles from Lake Herman and is in section J-6 (see Figure 3). It is 275 feet below Trap No. 5 and 510 feet above Trap No. 7. Trap No. 6 is the sixth trap in a series of eight traps, and it is in the same pasture as Traps No. 2-8.

Trap No. 6 is in a creekbed which is approximately twelve feet wide and two feet deep. The creek banks are not well defined and grade imperceptibly with the surrounding area. The creek bottom is covered for the most part with vegetation which consists mainly of grasses.

### Silt Trap No. 7

Silt Trap No. 7 is twenty-six feet long and three feet and three inches wide. It has three parts which differ in their heights. The main section of the trap is sixteen feet and three inches long and eighteen inches high. On each side of the main section is a wing. One wing is six feet and six inches long and one foot high. The other wing is three feet and three inches long and one foot high. The main section lies in the creekbed, and the wings are on the gently sloping creek banks.

Trap No. 7 is approximately one and one-fourth miles from Lake Herman and is in section J-6 (see Figure 3). It is 510 feet below Trap No. 6 and 1,470 feet above Trap No. 8. Trap No. 7 is the seventh trap in a series of eight traps, and it is in the same pasture as Traps No. 2-8.

Trap No. 7 is in a creekbed which is approximately fifteen feet wide and two feet deep. The creek banks are not well defined and grade imperceptibly with the surrounding area. The creek bottom is lacking in vegetative cover after this time.

### Silt Trap No. 8

Silt Trap No. 8 is forty-two feet and three inches long and three feet and three inches wide. It has two parts which differ in their heights. The main section of the trap is thirteen feet long and three feet and and three inches high. Only one wing is present. It is twenty-nine feet and three inches long and one foot high. The main section lies in the creekbed and has one end countersunk in the high, vertical bank. The wing lies on the gently sloping bank on the other side of the creek.

Trap No. 8 is approximately one mile from Lake Herman and is in section J-6 (see Figure 3). It is 1,470 feet below Trap No. 7. Trap No. 8 is the eighth trap in a series of eight traps on this branch of the creek, and it is in the same pasture as Traps No. 2-8.

Trap No. 8 is in the bend of a deeply eroded creekbed. The bank at the outside of the bend is vertical and lacking in vegetation. The other bank is ill-defined and grades imperceptibly with the surrounding area. The creek bottom is lacking in vegetative cover during the spring months. Sparse vegetative cover of invader species occurs during the summer months.

### Silt Trap No. 9

Silt Trap No. 9 is twenty-nine feet and three inches long and three feet and three inches wide. It has two parts which differ in their heights. The main section of the trap is thirteen feet long and three feet and three inches high. Only one wing is present. It is nineteen feet and six inches long and one foot high. The main section of the trap lies in the creekbed, and the wing lies on the creek bank.

The trap is approximately two miles from Lake Herman and is in section J-8 (see Figure 3). It is the farthest upstream of the four traps on this branch of the creek. Trap No. 9 is one-half mile above Trap No. 10 and is in a pasture. Cultivated fields lie approximately eighty to one hundred feet from each side of the creek as it flows through the pasture. The creek passes through a cultivated field one-eighth mile upstream from the trap.

Trap No. 9 is in a creekbed which is approximately seven feet wide and two feet deep. The creek banks are vertical and lack vegetative cover. Very little vegetation is found in the creekbed.

### Silt Trap No. 10

Silt Trap No. 10 is nineteen feet and six inches long and three feet and three inches wide. It has three parts which differ in their heights. The main section of the trap is six feet and six inches long and three feet and three inches high. On one side of the main section is a wing. Each wing is six feet and six inches long and one foot high. The main section of the trap lies in the creekbed, the wings are on the creek banks.

Trap No. 10 is approximately one and one-fourth miles from Lake Herman and is in Section J-7 (see Figure 3). It is approximately one-half mile below Trap No. 9 and is 525 feet above Trap No. 11. Trap No. 10 is the second trap in a series of four traps. It is in a pasture and is approximately 600 feet downstream from where the creek flows through a cultivated field.

Trap No. 10 is in a creekbed which is seven feet wide and two feet deep. The creek banks are vertical and lack vegetative cover. Very little vegetative cover is found in the creekbed.

## Silt Trap No. 11

Silt Trap No. 11 is thirty-nine feet long and three feet and three inches wide. It has three parts which differ in their heights. The main section of the trap is nine feet and nine inches long and three feet and three inches high. On each side of the main section is a wing. One wing is nineteen feet and six inches long and one foot high. The other wing is nine feet and nine inches long and one foot high.

Trap No. 11 is approximately one and one-fourth miles from Lake Herman and is in Section J-7 (see Figure 3). It is 525 feet below Trap No. 10 and one-third mile above Trap No. 12. Trap No. 11 is the third trap in a series of four traps and is in the same pasture as Trap No. 10.

Trap No. 11 is in a winding portion of the creek which is ten feet wide and two feet deep. The creek banks are nearly vertical and are sparsely covered with vegetation. The creek bottom is lacking in vegetation during spring months, but it later has sparse vegetative cover.

## Silt Trap No. 12

Silt Trap No. 12 is thirty-five feet and nine inches long and three feet and three inches wide. It has two parts which differ in their heights. The main section of the trap is nineteen feet and six inches long and three feet and three inches high. On one side of the main section is a wing which is sixteen feet and three inches long and one foot high.

Trap No. 12 is approximately three-fourths miles from Lake Herman and is in Section J-7 (see Figure 3). It is one-third mile below Trap No. 11. Trap No. 12 is the fourth trap in a series of four traps.

Trap No. 12 is in a slough-like expansion of the creek which is about thirty feet wide. The creekbed and creek banks are densely covered with tall vegetation which form a well-developed sod. About one-fourth of the vegetative cover is Reed Canarygrass (Phalaris arundinaceae). Giant ragweed, nettles, dogbane, grasses, and sedges are also present. The creek banks are not well defined and grade imperceptibly with the surrounding area.

Trap No. 12 is in a grassland area which is not pastured. A cultivated field lies several hundred feet to one side of the creek, but no cultivated fields lie directly between this trap and Traps No. 10 and 11.

## Silt Trap No. 13

Silt Trap No. 13 is seventy-eight feet long, three feet and three inches wide, and three feet and three inches high. All of its parts are similar.

Trap No. 13 is approximately one-half mile from Lake Herman and is in Section J-8 (see Figure 3). It is the farther upstream of the two traps in its series. Trap No. 13 is one-eighth mile above Trap No. 14 and is in a pasture which has cultivated fields adjacent to it.

Trap No. 13 is in a ravine that is twenty to twenty-five feet deep. The trap extends across the bottom of the ravine and part way up its sides. Because of this construction, water does not flow around the ends of the trap under any circumstances. The bottom of the ravine is partially covered with rocks and gravel. The rest of the ravine is covered with vegetation that forms a good sod.

## Silt Trap No. 14

Silt Trap No. 14 is eighty-seven feet and nine inches long, three feet and three inches wide, and three feet and three inches high. All of its parts are similar.

Trap No. 14 is approximately three-eighths mile from Lake Herman and is in Section J-8 (see Figure 3). It is one-eighth mile below Trap No. 13 and is the second trap of the two in its series. Trap No. 14 is in the same pasture as Trap No. 13 and is not near cultivated fields.

Trap No. 14 is near the base of a hill and in a small ravine that is approximately ten feet deep. The trap extends across the small creek in the ravine and part way up the sides of the ravine. The creek is fifteen feet wide and two feet deep. The ravine and the creekbed above the trap are densely covered with vegetation which consist primarily of grasses, sedges, and several invader species.

## Silt Trap No. 15

Silt Trap No. 15 consists of a vertical wall, such as found in Traps No. 1-14; but, in addition, it has lower gabions on its downstream and upstream sides, which are hereafter termed aprons. The central, vertical wall is eighty-one feet and three inches long, three feet and three inches wide, and three feet and three inches high. The apron on the downstream side of the vertical wall consists of two series of gabions which are immediately adjacent to each other and to the vertical wall. The first series of gabions (adjacent to the vertical wall) is eighty-one feet and three inches long, three feet and three inches wide, and one foot high. Thus, it extends completely across the front of the central, vertical wall. The second series of gabions in the downstream apron is fifty-eight feet and six inches long, three feet and three inches wide, and one foot high. It extends along the middle portion of the trap. The apron on the upstream side of the vertical wall also consists of two series of gabions which are immediately adjacent to each other and to the vertical wall. The first series of gabions (adjacent to the vertical wall) is eighty-one feet and three inches long, three feet and three inches wide, and one foot high. Thus it extends completely across the back of the central, vertical wall. The second series of gabions in the upstream apron is sixty-five feet long, three feet and three inches wide, and one foot high. It extends along the middle portion of the trap. Immediately in front of the upstream apron is a layer of loose rocks which is about one foot wide. Beneath one-half of the length of the trap is a layer of plastic screen (plain Poly-Filter X, Carthage Mills Incorporated, Cincinnati, Ohio). A well-developed sod is present under the entire trap.

Trap No. 15 is 625 feet from Lake Herman and is in Section H-7 (see Figure 3). It is the farther upstream of the two traps in its series and is 250 feet above Trap No. 16. Trap No. 15 is in a pasture and is approximately one-fourth mile below a cultivated field.

Trap No. 15 is in a ravine which is about forty feet deep and has steep sides. The ravine is well covered with vegetation which consists primarily of grasses. The trap extends far enough up the sides of the ravine that water does not flow around it under any conditions.

### Silt Trap No. 16

Silt Trap No. 16 is constructed in the same manner as Trap No. 15. It has a central, vertical wall and aprons on the upstream and downstream sides. The central, vertical wall is fifty-eight feet and six inches long, three feet and three inches wide, and three feet and three inches high. The apron on the downstream side of the vertical wall consists of two series of gabions which are immediately adjacent to each other and to the vertical wall. The first series of gabions (adjacent to the vertical wall) is thirty-nine feet long, three feet and three inches wide, and one foot high. It extends along the middle portion of the trap. The second series of gabions in the downstream apron is constructed in the same manner as the first series of gabions and also extends along the middle portion of the trap. The apron on the upstream side of the vertical wall consists of two series of gabions which are immediately adjacent to each other and to the vertical wall. The first series of gabions (adjacent to the vertical wall) is fifty-eight feet and six inches long, three feet and three inches wide, and one foot high. Thus, it extends completely across the back of the central, vertical wall. The second series of gabions in the upstream apron is thirty-nine feet long, three feet and three inches wide, and one foot high. It extends along the middle portion of the trap. Immediately in front of the upstream apron is a layer of loose rocks which is about one foot wide.

Trap No. 16 is 375 feet from Lake Herman and is in Section H-7 (see Figure 3). It is 250 feet below Trap No. 15 and is the second trap in this series of two traps. The trap is in a pasture and is approximately one-fourth mile below a cultivated field.

The nature of the ravine and the surrounding area is the same as for Trap No. 15 (see above). The trap extends far enough up the sides of the ravine that water does not flow around the trap under any conditions.

### Silt Trap No. 17

Silt Trap No. 17 consists of a vertical wall and two "step-down" aprons on the downstream side. The vertical wall is fifty-eight feet and six inches long, three feet and three inches wide, and three feet and three inches high. Adjacent to it and on its downstream side is a second series of gabions which are thirty-five feet and nine inches long, three feet and three inches wide, and eighteen inches high. Immediately adjacent to this "step-down" apron is a series of gabions which form a second "step-down" apron. This apron is twenty-six feet long, three feet and three inches wide, and one foot high. Smaller rocks (five to six inches in diameter) than were usually used were placed in the aprons and in the base of the main, vertical wall.

Trap No. 17 is approximately two and one-half miles from Lake Herman and is in Section E-7 (see Figure 3). It is the only trap built on the north creek.

Trap No. 17 is in a small ravine at the edge of a cultivated field. The ravine is about twelve feet deep and is well covered with vegetation. The creek which passes through this ravine is not well defined and grades imperceptibly with the ravine. The field has been planted in alfalfa for the past two years. The creek and strips approximately twenty feet wide on each side of it are not cultivated at any time. The trap extends far enough up the sides of the ravine that water does not flow around it under any conditions.